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The Exportability of the Dutch Offshore Wind Industry: A Case Study of Taiwan

Laura Elisabeth Jansen

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Supervised by

Prof. Maria Isabel Rebelo Teixeira Soares, Ph.D.

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Abstract

Economic diplomacy is an asset used by governments to create and utilize export opportunities. These opportunities depend on the status of the internal market and of the foreign market. This report explores the export opportunities for the Dutch offshore wind sector to the developing industry in Taiwan and how the Dutch government, industry and research institutions cooperate to make use of them. The report shows how the right application and functioning of the Triple Helix in a knowledge-based economy stimulates the continuous improvement of this knowledge and facilitates the export of it. To determine the export opportunities of the Dutch sector to Taiwan, both countries and their industries are studied and analysed. The market analysis of both countries allows for matchmaking between demand, in Taiwan, and supply, in The Netherlands. Demand might however also come from other foreign companies operating in Taiwan. This information is completed by an analysis of the current situation of Dutch activity in the Taiwan offshore wind sector and future plans and the role of economic diplomacy in these are discussed.

Key words: Triple Helix, Renewable energy industry, Export policies

JEL codes: O240, O38, O440

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Introduction

In March 2019 I started my internship at the Department of International Enterprises (DIO) at the Ministry of Foreign Affairs of The Netherlands. The main objective of DIO is stimulating sustainable economic development by strengthening the trade relations between The Netherlands and its trading partners. The department invests in the position and wellbeing of Dutch entrepreneurs operating internationally by strategically using economic diplomacy. Export is a crucial contributor to the Dutch economy as more than one third of its GDP is earned by export of goods and services (Central Bureau for Statistics, 2018). Therefore supporting and stimulating exporting Dutch entrepreneurs is important and deserves investments and attention.

The daily affairs and the course followed are based on the policy note of the minister of Foreign Trade and Development Cooperation, Minister Sigrid Kaag. In the trade policy note *Investing in Global Prospects* she states what course to sail for the next few years. In this policy note she writes with special attention about public-private partnerships, start-ups and female entrepreneurship. A main focus of the trade policy note is on the Sustainable Development Goals (SDGs) of the United Nations Development Programme (Kaag, 2018). More specifically, it explains how working towards a emission-free world is not a burden but rather that it creates opportunities. The SDGs should be considered as providing business opportunities and stimulate the country's economy. The trade policy note is leading for and reflects in the activities of the Ministry of Foreign Affairs and, for example, in the trade missions organized by the ministry.

As an intern policy officer at DIO, I worked in the Latin America cluster and for several other themes such as (international) corporate social responsibility and circular economy. My main task was to support the senior policy officers with their day-to-day pursuits. These included but were not limited to preparing trade missions for ministers, set up a sustainable economic strategy for Latin America, attend seminars, content preparation for meetings, events and conferences as well as work at the Global Entrepreneurship Summit. In addition to my normal duties I have written this report on the offshore wind trade relation of The Netherlands and Taiwan, as Taiwan is one of the most promising markets for the offshore wind industry due to their plans for development. The trade relation is considered by focusing on their individual industries as well as the cooperation between the two.

Of the SDGs, number 7 aims for affordable and clean energy for everyone. Stimulating renewable energy generation is the solution to achieve this goal as, once installed, it is an accessible and affordable way to produce energy without depending on fossil fuel production. With an increasing demand for energy and the pressure the conventional sources of energy put on the earth there is reason enough to switch to non-conventional, renewable sources of energy. The European Union (EU) as an example set the 20-20 target for 2020 to generate 20% of its consumed energy from renewable sources and improve its energy efficiency by 20% as opposed to 1990 by 2020, indicating that 34% of the electricity generation should come from renewable sources (European Wind Energy Association [EWEA], 2011). The type of renewable energy is country and situation dependent. For countries in North-western Europe for example, generating solar energy is not the most effective way of generation. An appropriate solution for replacing fossil fuels is generating energy through wind power. A more region-specific solution is the generation of wind power through offshore wind farms.

For the department in which I performed my internship, DIO, this means an extra focus will be put on exploring and using the possibilities and opportunities of the Dutch renewable energy sector. One of the ways of generating renewable energy in which the Dutch have a leap when compared globally, is the offshore wind industry. Wind mills have always been of great value for the Dutch economy. Already in the 12th century the first wind mill was built near the shore of the North Sea. In the centuries that followed, this spread throughout the country and the wind mill became a staple part for the grinding process of grains. Later the wind mills got additional functions such as the drainage of polders, another traditional and characteristic element of Dutch culture and history. Only at the end of last century generating electricity was added as a functionality of wind mills and half a decade ago this technique for offshore generation. In the initial phases this was a technique that was not competitive with any type of conventional generation. However, during the past decades global interest has grown and many countries explore their options to develop offshore wind farms.

The increasing demand for renewable energy, as is offshore wind, creates opportunities for countries that have expertise due to experience. It creates opportunities to export their knowledge and know-how and at the same time contribute to the development of global sustainable electricity generation. It thus is an example of gaining with the SDGs, a central theme in the trade policy note and a key objective of DIO. For a government to support the export of an industry, it does require detailed information on the main players and on the unique selling points that these players have to offer. So to say, it requires the government to work together closely with the industry and the involved research institutions. At the same time it is important to know the status of the industry and its supporting policies in the country to which export is foreseen.

The main objective of this report is to explore the opportunities for the Dutch offshore wind sector in Taiwan and the Triple Helix and economic diplomacy can support this. The report will start by considering the relevant theories to understand the situation. The situation where a country has strong global position in a renewable energy industry caused not only by experience but also by national factors such as government support and strong research institutions. At the same time international factors like increased demand for renewable energy due to local policies and global climate agreements contribute to the possibility to export this industry. To focus on the export of the Dutch offshore wind industry, the overall industry will be introduced and analysed, followed by an analysis of the Dutch industry and its strengths. Hereafter a focus market will be discussed, namely Taiwan. The country is introduced and its offshore industry is analysed, focusing on the country specific challenges and opportunities. For this, knowledge of experts about the market is included in the analysis. Finally the current presence and participation of the Dutch offshore players in Taiwan is established and potential improvements of the export relations are looked at.

Theoretical framework

Exporting knowledge and experience

The obvious and basic formula for export is the supply by one country for the demand of another country. This basic formula is of course influenced by many other factors, internal factors from the country that will export and external factors coming from the demanding country. At the same time it is not a closed formula as the setting is international and other global factors might influence the export as well. Also, the export formula is not equal or comparable for all industries. In the renewable energy technologies industry, it requires the exporting country to have a well-developed technology and the importing country to have motives to develop a renewable energy industry.

In the case of The Netherlands, export is supported and stimulated by the integrated cooperation of governments, research institutions and industries. These work together to not only improve the inland innovation but also to facilitate the knowledge-based export. In many cases, especially when exporting a knowledge-based product or service, timing is important. In some cases timing might give a company or industry a leap or advantage and in other cases timing is crucial for successful export, for example in the case of continuous technological improvement. This is the so-called first mover advantage. Whereas these internal factors are important for facilitating export, the situation in the importing country does also affect the export. For both the exporting and the importing country, policies should be favourable for the export to take place. In the case of renewable energy industries, this means that favourable renewable energy policies can positively influence and facilitate the export of it. These theoretical concepts are all relevant for the case of exporting the Dutch offshore wind industry to Taiwan.

Triple Helix

For economies to optimally use its capacity it is important that there is good cooperation between the government, industries and universities. This cooperation was first referred to as the Triple Helix by Etzkowitz and Leydesdorff (1995). Before their publication, universities were generally seen as a separate entity, especially in relation to industries. In their publication the authors observe how governments stimulate universities to contribute to economic growth, for example by providing education and research for important sectors of a country (Etzkowitz & Leydesdorff, 1995). Interaction between the three entities will create new, trilateral institutions that by supporting industries and export, contribute to the economic wellbeing of a country (Etzkowitz & Leydesdorff, 1995). When universities, by performing researches, industries, by producing goods, and governments, by regulating the market, cooperate closely, innovation will be the result which will contribute to the competitive advantage of a country in the global economy.

An example of the Triple Helix functioning in knowledge-based economies is the creation of clusters. Governments connect companies from the same industry in a similar geographical region to cooperate and together reach a higher level of innovation (Cooke, 2002). These clusters might also include research institutions and governmental organizations. They work together to obtain a cooperative advantage and increase national competitiveness to reach economic development (Cooke, 2002). In these clusters, Cooke (2002) argues, research funding and financial investment and management are indispensable. These clusters can also operate on an international level or cooperate with international parties. For a small country like the Netherlands, joining forces is important to make an impact on an international market.

Knowledge-based economies

The successful implementation of the Triple Helix model is often a part of a knowledge-based economy. Leydesdorff (2006) uses the model to concretize the broad concept of knowledge-based economies. By applying the model to the specifics of a knowledge-based economy, Leydesdorff explains how layers of institutional and functional relations influence the different bodies of the model. This means that the relation of industries and universities can arrange agreements between the two bodies that are advantageous for both. Although the bodies are autonomous and independent, the right cooperation will contribute to knowledge creation. Knowledge creation is the base of knowledge-based economies and can serve as export leverage for the economy.

Powell and Snellman describe the knowledge economy or knowledge-based economy as the "production and services based on knowledge-intensive activities that contribute to an accelerated pace of technical and scientific advance, as well as rapid obsolescence" (2004, p. 199). Throughout the history of economics, knowledge has not always been recognized as an important factor. Until the 1950s the contribution of knowledge to economic growth was considered as being a detail and the traditional factors of land, labour and capital were thought of as being the main reasons for economic growth (Abramowitz, 1956). Rosenberg (1976) introduced the importance of knowledge for the wellbeing of an economy. Rosenberg argues that technological innovation, arising from strong knowledge-based industries will contribute to economic growth.

An innovative knowledge-based economy is not only important for the inland production and industries, it is also an important asset for export. As Krugman (1979) explains, a region that focuses on technological innovation retains its competitive advantage and will have higher incomes from export. Krugman also emphasizes the importance of continuous investments and improvement in the technological advantage that a country or region might have. The offshore wind industry is one that requires continuous investment and improvement as well. A large share of the supply chain involves complicated technology that is continuously improved and, to retain a competitive position, investments in research and development (R&D) is required.

In the offshore wind industry knowledge and expertise is still rather concentrated in the countries surrounding and participating in projects in the North Sea. Even though countries like China are quickly and strongly growing their industries, one could still speak of a cluster of knowledge. Cooke (2002) argues that in modern-day economies it is common that knowledge is geographically clustered. He therewith explains how these knowledge clusters need a support system in order to survive and retain its competitive advantage (Cooke, 2002). This system required to support knowledge-based economies can be based on financial aid, right funding and research, which in turn are results of a strong Triple Helix model.

First mover advantage

Being the first to start producing a product or selling a service gives a company an advantage and a lead on others. The same is true when it comes to being the first to export a product or service to a new market. Lieberman & Montgomery acknowledge this advantage as the first-mover advantage (FMA) and allocate this advantage to "technological leadership, pre-emption of assets and buyer switching costs" (p. 43, 1988). The FMA results in a larger market share and a higher chance of surviving (Lieberman & Montgomery, 1988). Technological leadership is obtained due to experience that leads to a learning curve, giving the company a cost advantage in its production. Spence (1981) claims that this learning curve is strategically used by the first mover to create a barrier for new entrants, making it a proprietary advantage. To keep this advantage while entering new markets a company will sell under the break-even price in order to win territory in the new market (Spence, 1981). The Boston Consulting Group described this as a sustainable cost advantage for early market entrants (Lieberman & Montgomery, 1988). Another reason for technological leadership of the first mover is the advanced R&D, giving the company an advantage of product of process technology (Lieberman & Montgomery, 1988). Innovation results in an improved production process or organizational structure, which is a way of 'moving first' and gaining competitive advantage. In the case of the development of offshore wind farms, still many are developed with the support of local governments in the form of subsidies. With the support of subsidies or specifically a Feed in Tariff (FiT), a strong cost advantage is of less importance. Therefore the question arises whether these types of cost advantage of the first-mover will be a decisive factor in who has the greatest advantage. Another advantage of moving first is the pre-emption of (scarce) assets, which is the advantage an early mover has when acquiring assets that might be scarce, for example minerals or access to oil-rich surfaces (Lieberman & Montgomery, 1988). Also there is the advantage of buyer switching costs, which indicate the costs a company would have to make to convince a client to buy his product or service, giving the first mover a cost advantage (Lieberman & Montgomery, 1988). In the case of entering new markets in the offshore wind industry this advantage is not that obvious. The first movers that try to export to a new market will in some cases have to compete with local companies that have the strong advantage of being local.

Due to the complexity of export of the offshore wind industry, the theory of the FMA is not one-on-one applicable. As mentioned, the industry today still very much depends on subsidies and strong regulation. Beise and Rennings (2005) state that an export advantage in the (offshore) wind industry arises when the export market has similar market conditions and regulations as the home market. Denmark, for example, is the leading country when it comes to exporting the wind industry. This is attributable to its strong regulation of the market and its international policy diffusion, also known as the Porter effect (Beise & Rennings, 2005). The Porter effect explains how efficiency and innovation in renewable energy production and more competitiveness can be encouraged by strong environmental regulation (Porter & Van der Linde, 1995). The FMA in the case of offshore wind industry will need to be supported by adequate regulation in the export market in order for it to function.

Environmental regulation and renewable energy policies

Beside the generic favourable conditions for a successful export of a knowledge-rich industry, there are also some specific theories that underline the importance of (renewable) energy policies and environmental regulation. In the case of the offshore wind industry, both the policies and regulations of the exporting as well as of the importing country are relevant to understand the export possibilities.

Porter and Van der Linde (1995) focused on the role of environmental regulation in the competitiveness of a renewable energy industry. More specifically, they explain how environmental regulation and the establishment of standards and limits will basically stimulate innovation, as a way to meet the required standard or limit (Porter & Van der Linde, 1995). This innovation will lead to "offsets" that will lead to cost reduction, and therewith increase the competitive advantage (Porter & Van der Linde, 2016, p. 98). So, whereas environmental regulation is sometimes considered as restrictive and opposing competitive grow, it can also lead to innovative solutions that will not only contribute to cost reduction but also to an improved position in the global market.

Beside economic regulation in the sense of establishing standards, a government can also focus more on policies related to renewable energy industries. Sung and Song (2013) show that there is a causal relationship between policies and the export of renewable energy technologies. It is known that for renewable energy technologies a constant improvement in technology is needed to maintain or develop a competitive advantage (Sung & Song, 2013). The same goes for the offshore wind sector. Sung and Song claim that whereas in some industries experience in 'doing' or 'scale increase' will lead to cost reduction, for renewable energy technologies this generally is obtained by R&D and that this can lead to a 25% cost reduction (DNV GL, 2018). A cost reduction and an improved technology is a strong combination to create a competitive advantage in the international market. However, this is a two-directional effect as increased export can also lead to increased R&D investments, as export leads to increased financial assets (Sung & Song, 2013). An export focus from the government, by the creation of long term export promoting policies, will lead to increased exports, which in turn will generate financial capital and stimulate R&D.

Lund (2009) also emphasizes the importance of the right regulation and policies for the growth of renewable energy industries. He states that for a strong industrial position, a country does not necessarily have to have a strong home market, a home market being the demand for the industry in the country itself (Lund, 2009). Home markets however do tend to grow when renewable energy policies are prioritized (Lund, 2009). These policies do mainly create opportunities and stimulate export of the industry. In order for a government to create adequate and effective policies, the different phases of the value chain should be analysed in order to establish in which phases the strengths of the country's industry lies (Lund, 2009). A small part of the renewable energy systems, about 30 – 40%, is made up of technologies that are used in other, traditional energy sources as well (Lund, 2009). This might for some countries be a disadvantage however for other, with experience for example in the offshore oil and gas sector, it will be a leap. Lastly, Lund (2009) emphasizes the importance of external influencing factors on the development of renewable energy industries, such as timing and geographical location. This timing is especially important when focusing on exporting the offshore wind industry. Not only because of the first-mover advantage, yet also the accurate timing to align the export with the plans of other countries, for example in the case of tenders.

Offshore wind policy development in The Netherlands

In the case of the Netherlands and its offshore wind industry, the course of the government has gone through several stages. Verhees, Raven, Kern and Smith (2015) describe these stages in their analysis of several time periods. The interest for offshore wind started in 1973 as a result of the global oil crisis (Verhees et al., 2015). The crisis made the country consider alternative sources of energy, although the focus around then was more on onshore wind and energy saving (Verhees et al., 2015). As The Netherlands is a country with a small surface and a relatively dense population, spatial planning and the Not In My Backyard-effect soon created problems for the expansion of onshore wind parks, leading to growing interest in offshore generation (Verhees et al., 2015). Around 2000, serious and ambitious plans were made for the construction of large offshore wind farms and the private sector started to develop interest in the industry as well (Verhees et al., 2015). In the years to follow, however, a change of government was accompanied by a loss of interest in the industry, as it was considered as too costly and too subsidy-dependent (Verhees et al, 2015). When around 2007 the shift of attention to climate change took place, so did a renewed interest in the offshore wind industry. Subsidies are reinforced and the national and inland industry starts to grow (Verhees et al., 2015). Interesting is that in 2010 a more centre-right cabinet comes into office and decides to focus on innovation investments rather than subsidies (Verhees et al, 2015). As Porter and Van der Linde (1995) and Sung and Song (2013) argued, focus on innovation will lead to cost reduction and improved technologies, which together form a strong basis for an improved competitive advantage. And indeed, the in 2011 established goal of 40% cost reduction by 2020 in the development of offshore wind farms was already transcended to 55% in 2018 (PwC, 2018b). Another result of the course taken in 2011 is the improved cooperation between public and private parties. The government created a Top Consortia for Knowledge and Innovation (TKI), a partnership between industry and knowledge institutions, for the offshore wind industry (Verhees et al., 2015). This TKI is a good example of the functioning of the Triple Helix.

Exporting the Dutch offshore wind industry

The theory that discusses the motives for a competitive advantage and a strong export potential do mainly focus on the internal factors that influence this. The environmental regulation that might induce innovation and cost reduction, the renewable energy policies to stimulate the national market and industry and the cooperation of government, industry and knowledge institution to pursue R&D are examples of this. The formula of export does however include two parties: the exporting and the importing country. In order for the formula to be successful, both should be considered.

In The Netherlands at first the focus was on the role of the offshore wind energy in the inland energy transition, for which the TKI Wind on Sea was established. At the end of 2017, a new concept was created in the sector with a stronger focus on the export of the industry, known as Wind & Water Works. The Dutch Enterprise Agency (RVO) explains that it was created in order for the government and the industry to work together with the shared objective of exporting the experience and expertise of the Dutch offshore wind industry. The ambition to export exists and the national preparations have been made. What is next is the pro-active participation in new markets. To successfully participate, however, a good understanding of the country and the market is necessary. The development of an adequate export strategy requires a clear picture of both internal and external factors. This report will contribute to this clear picture in order for the export strategy to be in line with the situation in both countries, which eventually decides supply and demand.

The first part of the report starts by making an analysis of the offshore wind industry to create a base for the remainder of the report. The specifics and the state of the art of the industry are discussed as well as certain challenges and advantages of offshore wind. This general analysis will be followed by the second part, a consideration of the Dutch offshore wind industry with a focus on determining the strengths of the country. As Lund (2009) described, analysing the internal market and its strengths is crucial to establish export promoting policies. In the third part of the report this will be discussed and finally, in the fourth part, an analysis of the Taiwanese development plans and the opportunities for The Netherlands are considered.

Introduction to the industry

The developing industry

The offshore wind industry is a rather young one and one that is about to be developed worldwide. Three decades ago it was first explored in Denmark and from there it started to develop in the countries surrounding the North Sea (Environmental and Energy Study Institute [EESI], 2010). The North Sea has a great potential for the generation of wind energy due to the high wind speeds (see figure 1) and shallow water (Rodrigues, Restrepo, Kontos, Pinto & Bauer, 2015). These beneficial characteristics in combination with the need for non-conventional ways of electricity generation create a good motivation for the exploration and extension of the offshore wind industry. The countries that first started exploring the industry, Denmark, United Kingdom, Germany, The Netherlands and Belgium, are the ones with the largest installed capacity today. China, however, has caught up and is now the country with the third largest installed capacity. The countries with the largest installed capacity are most experienced and therefore have an advantage on knowledge possession as well.

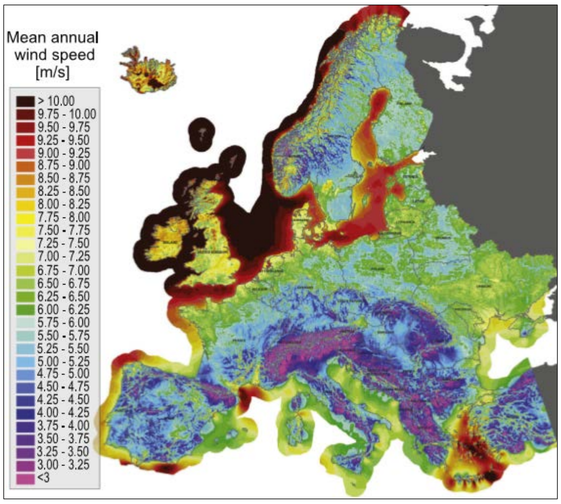


Figure 1: Mean annual wind speed at 80 m height (Rodrigues et al., 2015)

In the last eight years a strong increase in installed capacity occurred, with in 2017 a total offshore wind capacity of 18,814 MW (see figure 2) (IRENA, 2018a). In 2018 another 4 GW was added to this capacity (IRENA, 2018a). Whereas the majority of offshore projects for a long time were mainly developed in the countries surrounding the North Sea, last year China installed more capacity than any other country. China installed 1.8 GW whereas the United Kingdom 1.3 GW and Germany 0.9 GW (GWEC, 2019).

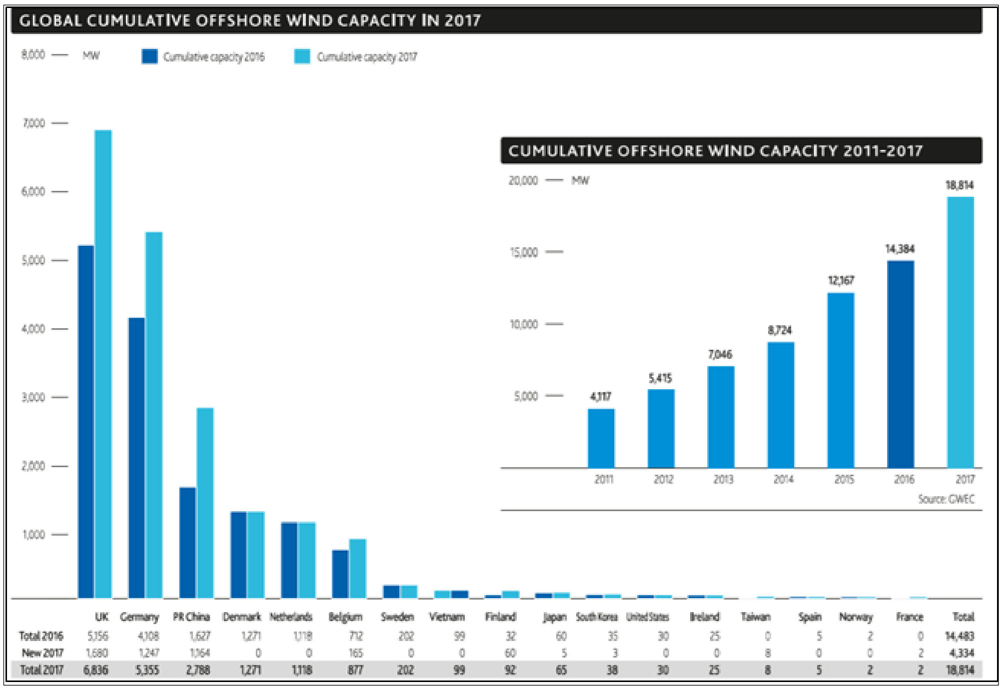


Figure 2: The global cumulative offshore wind capacity (GWEC Global Wind 2017 Report, 2017)

Planned and expected installed capacity

As the costs for offshore wind projects are falling and knowledge is increasing, interest grows. Mid 2018 globally there was about 20 GW of installed capacity and for 2050 this is expected to grow to 520 GW (IRENA, 2018c). This increase in installed capacity is a combination of new to be developed projects and replacing already installed turbines, around 2030, due to their ending economic lives (IRENA, 2018c). Replacing them will give the opportunity to increase the capacity of the existing wind farm. The expectation are however open for change as new technologies and innovative improvements might change in the years to come.

The EU also acknowledges the important contribution offshore wind generation can make to accomplish the goals set in the Paris Climate Agreement. They announced that in 2030 the North Sea will have an installed capacity of 150 GW (Rodrigues et al., 2015). To reach this the industry is supported by the European Commission through research and innovation support, focusing both on the shallow waters of the North Sea as well as the development of floating structures for deeper waters.

The interest in the offshore wind industry is thus not limited to Europe and nor are the benefits. For the upcoming years many countries worldwide are developing their offshore wind farms, among others Australia, Canada, China, India, Japan, South Korea, Turkey and the USA (IRENA, 2018b). IRENA, the International Renewable Energy Agency, suggests and promotes the international cooperation in developing offshore wind farms in these new markets, so they can benefit from lowered costs and best practices of more experienced countries (2018b).

Offshore generation

Offshore wind farms produce energy by the wind turbines that are installed in water. Usually seas even though other types of onshore water, such as rivers, are also adequate. The wind causes a difference in pressure between the front and the back of the blades, which results in a force that makes the blades move, creating kinetic energy (TenneT, 2018). The nacelle to which the blades are connected transforms the kinetic energy of the wind into electrical energy (TenneT, 2018). The turbine is connected with submarine cables to an offshore platform. This platform, to which multiple farms can connect, increases the voltage after which it is connected to an onshore transformer station (TenneT, 2018). This transformer station increases the voltage so that it is connectable to the onshore high voltage grid (TenneT, 2018).

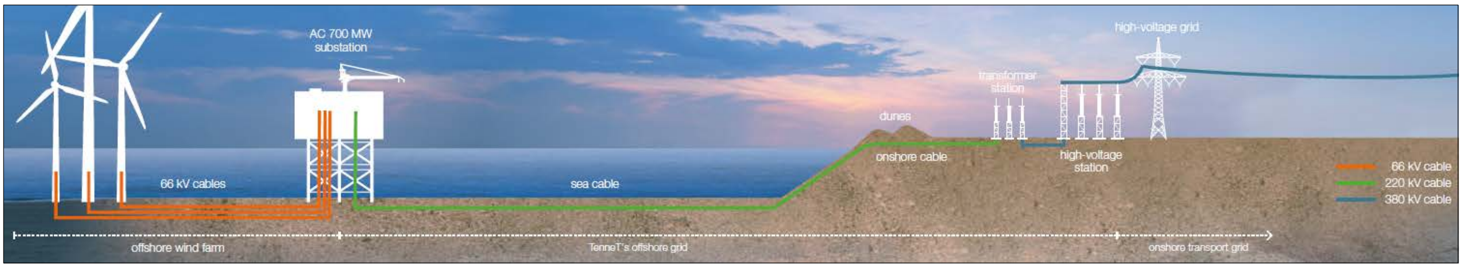


Figure 3: Offshore connected to onshore grid in The Netherlands (TenneT, 2018)

Onshore grid connection

There are several challenges to connecting the offshore generated electricity to the onshore high voltage grid. One of them is the fact that the offshore wind turbines are generating intermittent energy. Wind energy is not constant due to the different wind speeds that occur during different phases of a day. This creates variability in the energy production and due to the absence of adequate technologies to store electricity on a large scale, there is a need for conventional power to compensate the intermittent energy production (Siemens, 2014). Another challenge is the increasing distance from shore of the to be developed wind farms. Increased distance offshore means that the electricity has a longer traveling distance to reach the onshore grid connection. The offshore wind farm and the onshore transformer station need to be connected by submarine cables, which is a costly element of the production chain. Simultaneously a larger distance means higher loss rates during the transport of the electricity. However, experience and constant innovation offer solutions for these challenges. For example the Dutch Transmission System Operator (TSO) TenneT started using cables from the platform to the onshore transformer station with a capacity of 220 kV, consisting of three conductors (TenneT, 2018). This adaption increases the efficiency of the transportation. Also, for wind farms located further offshore, the connection to onshore will be direct current (DC), whereas the connection of short distances will have be alternating current (AC) (TenneT, 2018). The use of DC for larger distances decreases the loss during the transportation of the electricity to onshore.

Environmental challenges

Also when it comes to environmental challenges, experience and research lead to innovative solutions. In The Netherlands, various research institutions are dedicated to investigating what impact the construction and the existence of an offshore wind farms has on the different aspects of the ecosystem. An important part of the project development is the Environmental Impact Report, steering the project developer in the right direction to minimize its negative environmental impact (TenneT, 2018). In this report breeding birds and migrating birds above sea level and sea or water animals and plants underwater are not disturbed or harmed (TenneT, 2018). Simultaneously the project developer should consider making a positive environmental impact, for example stimulating biodiversity by facilitating an artificial reef on their platforms (TenneT, 2018). Environmental challenges that occur in to be developed projects can be solved by best practices from other developers, minimizing the environmental impact.

Spatial advantages

The ocean, seas and other water surfaces are full of potential and the capacity it offers is still underdeveloped. A major advantage of offshore rather than onshore installation is the limited space onshore. The installation offshore does not take up living space nor does it spoil landscapes. A particular problem of onshore wind turbines is the 'Not In My Backyard'-mentality. In the case of wind turbines, people generally agree with their installation as long as it is not close to their homes (Pee, Küster & Schlosser, 2017). This onshore problem does not exist with offshore wind farms. Overall, offshore wind farms have a larger social acceptance than onshore.

Besides this first spatial advantage, onshore wind generation has a smaller generating capacity due to the limited and less stable wind speed on land than offshore (Lynn, 2012). The generating capacity, as such, is higher offshore. This higher generating capacity makes up and compensates for the higher costs found in installing the turbines and the operation and maintenance (Wüstemeyer, Madlener, & Bunn, 2015).

For many countries the installation of offshore wind farms is not only a solution for the generation of clean energy, it also offers a solution for supplying large urban regions with electricity. The urban regions are the regions where most electricity is needed and many of these regions are situated close to shore (IRENA, 2018c). As onshore wind farms and solar farms are usually more difficult to construct close to cities due to the densely built spaces, offshore wind parks can offer a solution.

Reducing costs

The advantages did not remain unnoticed and there is a worldwide growing interest in the industry. This interest ensures the continuous commitment to improve the industry and the project development. Governments, knowledge institutions and businesses work in many cases together, to optimize the technology and reduce costs. The government of the Netherlands for example had set a goal to reduce the costs in the Dutch offshore wind industry by 40% by 2020 (TKI Wind op Zee, 2015). However, these costs have already been reduced by 55% (PwC, 2018b). This means that that in 2016 the tenders of Borssele I and II were sold at €72.70/MWh, Borssele III and IV at €54.50/MWh and in 2017 the tenders for Hollandse Kust Zuid were sold without subsidies to project developer Vattenfall. This is the first subsidy free offshore wind farm that will be developed, even though earlier that year three subsidy free projects were sold in Germany, won by enBW and Orsted (PwC, 2018b). Hollandse Kust Zuid will be a wind farm of 350 MW and its construction will start in 2022 (Deign, 2018). The subsidy free projects sold in Germany and The Netherlands can be explained by the decreasing levelized cost of energy (LCoE, a calculation of total costs along lifetime of wind farm and its expected production) as presented in figure 4 and the role the government plays in project development (Deign, 2018). Policies can indirectly stimulate cost reduction, by supporting innovation, by providing consistent and long term policies and establishing an attractive investment climate (TKI Wind op Zee, 2015). In The Netherlands, the government takes responsibility for the costs for site studies and the national TSO TenneT takes responsibility for connecting the energy generated by the offshore wind turbine to the onshore grid network (Rijksdienst Voor Ondernemend Nederland [RVO], 2017). This financial support allows Hollandse Kust Zuid to be developed subsidy-free.

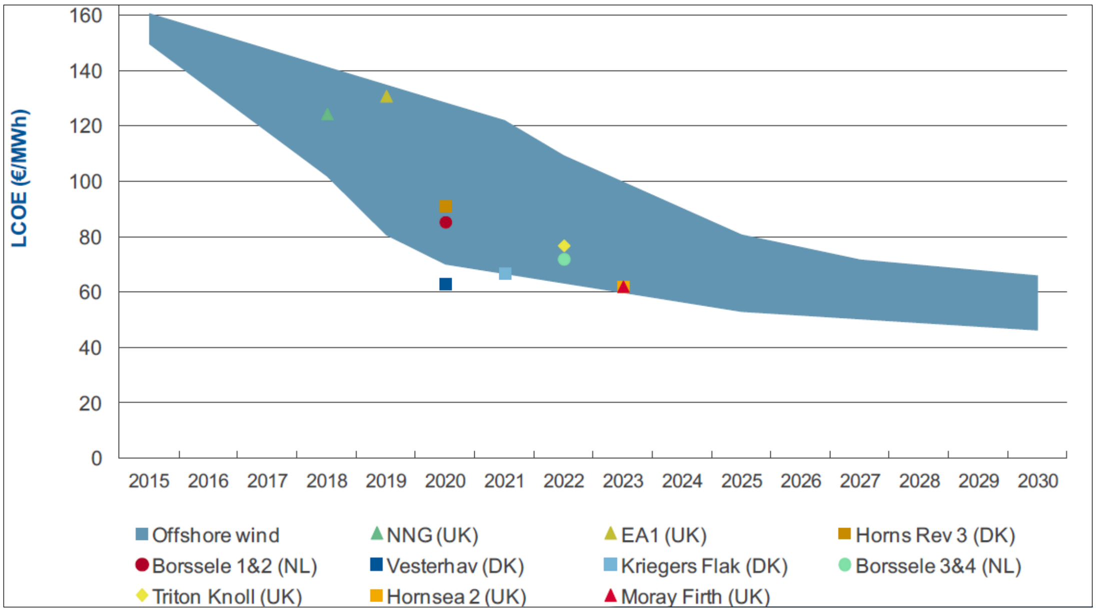


Figure 4: Levelized Cost of Energy in offshore wind farms in Europe (WindEurope, 2017)

Policies

Verhees et al. (2015) have described the importance of governmental support in the industry in The Netherlands. The government, as part of the Triple Helix, contributes to the successful development of the industry by creating the right supportive policies, by providing subsidies and by stimulating research institutions in the field. Adequate and well-designed policies will support the industry and lead to cost efficiency. Three elements that are important in the creation of supportive policies are: site specific auctions, winner selection and contract design (IRENA, 2017). If a government pre-selects the site where a wind farms is to be developed, the project developer is released from a large share of investigation. In this way the developer can focus on its financial and technical capabilities and after winning the bid focus on the specific features of the site. Policies regarding the selection of a winner will enable a country to demand a minimum price or demand specific requirements for the project developer. After a winner is selected, the government should apply its policies for setting up the contract. In the contract the liabilities of both the project developer and the government are stated. In the first case of a subsidy-free tender in Germany, the starting date of the project will be in 2024 or 2025 (Deign, 2018). The project developer is relying on constant technological innovation which enabled him to make a bid with no subsidy support (IRENA, 2017).

Technological improvements

Besides the influence of appropriate policies on reducing costs, technological improvements do strongly influence this as well. In all phases of the project innovation in technology will help decreasing costs. The reduced LCoE is explained by the continuous technological improvements in turbine design and in the innovation in other parts of the supply chain (Ashuri, Zaaijer, Martins, Van Bussel & Van Kuik, 2014). An increased turbine size for example boosts the generating capacity and therewith decreases the LCoE. Improved and cost-efficient foundations and methods of installation and (floating) platforms are also contributing factors (IRENA, 2018d). Not only do technological improvements contribute to lowering LCoE, they also make the industry more competitive and enlarge the group of countries that can access the industry. For some countries the interest in the industry is growing due to technological advancements that enable wind farms further offshore and in deeper waters (IRENA, 2018d). An example of a technique that is currently being developed and improved is the floating offshore wind farm. This is still in the developing phase and right now the techniques are tested through experimental farms. When considering the height of the LCoE, there are also external factors that need to be considered such as the price of iron and steel.

The technological innovations and overall gained experience in the developed markets can be of great value for the developing markets. If countries start exploring their possibilities for an offshore wind farm without prior experience, they will encounter high LCoE. Whereas more experienced and mature markets might be able to reduce these costs due to their knowledge, newer technologies and overall best practices (GWEC, 2019). So by cooperating with more advanced industries, starting industries can develop cost-efficient projects.

Industry analysis

Before identifying the main players and the strength of the Dutch players in the industry, it is important to establish the different segments of the supply chain and what the industrial process looks like.

1.	Design & development
2.	Turbine
3.	Foundation
4.	Substations & cables
5.	Logistics & installation
6	Operation & maintenance

Figure 5: Different segments of offshore wind energy (PwC, 2018a)

Design & development

The initial phase of developing an offshore wind farm is deciding on the location. Preliminary studies need to be done in order to make such a decision. This spatial planning requires site studies to determine the characteristics of the location such as wind speed and how it varies, depth of water, distance to shore, possibility to connect to the grid as well as geophysical studies on the seabed (Bruijne, 2017). To more accurately establish the environmental impact of the farm development on the specific site and prevent damage, an Environmental Impact Assessment (EIA) study has to be done (Splunder, 2017). Besides these more physical characteristics of the site, a study to the landowner of the site is also part of the planning phase. In usual cases the site of construction belongs to the government, making them responsible for determining the specifications of the to be constructed wind farm (Bruijne, 2017). In most projects developed in Europe, the responsibility and costs of these studies is taken by the government. This is part of the explanation of the subsidy-free tenders in Germany and The Netherlands.

After the location is decided upon and the specific details of the site and project are known, the project will be awarded to a project developer. In all known cases at this moment, this is done by rewarding contracts through tenders (PwC, 2018a). A single contract can be rewarded to a project developer who will subcontract different parts of the project. Or, in other cases, during the tender several contracts for different parts of the project are rewarded to different companies, spreading the responsibilities for the project. In these contracts, the financing of the project also needs to be stated (PwC, 2018a). After this, the project developer can start developing the logistics and the installation of the project.

Export: A part of this segment is in most cases carried out by government institutions. For some of parts, like the project development plan, financial studies and the EIA, consultancy firms can export their services.

Turbine

The construction of the actual wind turbine makes up the largest share of the value chain. It is a heavy construction of which the technology and the know-how is concentrated in a small amount of companies. The turbine consists of blades, a nacelle and a tower.

The **blades** 'catch' the kinetic wind energy which makes the blades rotate, generating electrical energy in the nacelle (Ng & Ran, 2016). The most common design used for blades in wind turbines today is a three-bladed design attached to a horizontal axis. This design is used for onshore installations as well, as it is an adequate design with minor pollution due to its minimal noise and size (Ng & Ran, 2016). These factors are of less importance for offshore installations (Jaax, 2016). Therefore alternative designs (e.g. with two blades) are now considered and tested as well.

The production of blades is complex and its design has a major influence on its generating capacity and its efficiency. For its production fibre glass is the most common material used, whereas aluminium can be used as well (LM Wind Power, 2018). Due to the importance of its design, there should be a constant search for innovation to increase its efficiency. At this moment increased capacity still goes paired with increased blade size, meaning an increase in weight as well. This makes it harder to transport and therewith harder to export.

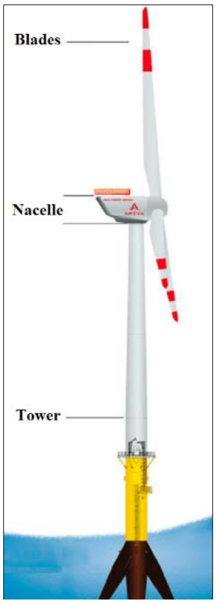


Figure 6: Components of a wind turbine (Jaax, 2016)

Export: Exporting blades over long distances or overseas is not profitable. For blades local production is thus needed to save costs.

The **nacelle** is connected to both the blades and the tower. Inside the nacelle there is a gearbox that transports the kinetic energy generated by the blades to the generator of electricity. This gearbox is left out in some cases, in which a direct drive concept applies (Lagerwey, 2015). In the case of a direct drive, less maintenance is required is required throughout the lifetime of the wind turbine (Lagerwey, 2015). However it does mean the overall nacelle will be heavier (Lagerwey, 2015). In the nacelle there also is a power control system that manages the exact position of the blades and might overall stop the blades moving when needed, for example when a storm occurs or when maintenance is needed (Ng & Ran, 2016). Due to the gearbox inside the nacelle, the component is complex and heavy, increasing the importance of a capable and strong tower and foundation. The nacelle is heavy and complex at the same time. It requires specific knowledge and certain machines to produce.

Export: Specific knowledge can of course be exported. For local production the consideration of cost-advantage should be made, as the machinery used for production is costly.

The blades and nacelle are connected to and carried by the **tower**. The two most common constructions for the tower of the turbine are the tubular and the truss, tubular being the most common (Kurian, Narayanan & Ganapathy, 2010). A tubular construction is made by joining steel elements, which is done onshore. The truss construction is a more flexible, material-saving but more expensive and less resistant option, making it a less common construction (Sharpley, 2013). Of the three elements mentioned, the tower is the least complex, it is however a heavy structure.

Export: Due to its relatively easy production yet heavy structure, local production is recommended as the costs to transport the tower cannot compete with the advantage and cost savings of local production.

Foundations

To secure the turbine structure in the water bottom, a foundation is needed. As the North Sea was the setting for most wind farms developed throughout the past decades, there were a few foundations that have been used most frequently. Of these structures (see figure 7) the most commonly used is the monopile, followed by gravity based and jacket foundations (Lynn, 2012). A monopile foundation is the simplest structure and can be used for depths less than 15 meters, a gravity based structure is heavy and for depths up to 20 meters and the jacket structure for depths over 30 meters (Iberdrola, n.d.) However considering increased depth means increased costs, this option is not feasible for deep water constructions.

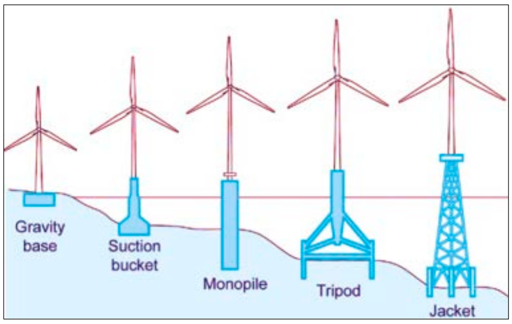


Figure 7: Types of foundations (Moulas & Mehmanparast, 2017)

As wind farms are to be developed in waters with very distinct depths, experiments with floating wind turbines are done. At this moment the floating structures are still very costly and need to be developed further in order to reduce costs and make it a feasible solution for deeper waters.

Export: Due to the size of the foundation and the relatively easy construction, for export to countries that are further away it will be more cost-efficient to produce locally rather than export the product.

Substations & cables

There are two different types of cables needed to transport the electricity onshore. Array cables are cables with a capacity of +/- 66 kV of alternating current (AC) that transport the electricity from the turbine to the substation (TenneT, 2018). At the substation the electricity is transformed, increasing the voltage to about 220 kV. From the substation, sea cables transport the electricity either AC or direct current (DC) to an onshore transforming station (TenneT, 2018). The decision for AC or DC depends on the distance to shore, AC for shorter and DC for longer distances of more than 60 km (TenneT, 2018).

Export: Both array and sea cables are exportable to developing markets, if not present in the country of development. Substations on the other hand are heavy and hard to export due to its size. For long distance export destinations local production will be the best solution.

Logistics & installation

After fabricating the different parts that make up a wind farm, the phase of installation starts. Installing a wind turbine can be a challenge due to rough conditions if installed offshore in deeper sea waters. Before starting installation, the sea bed of water bottom should be prepared for installation. After this is realized, the different parts can be transported to the destined location. All main parts of the wind turbine have their own installation vessels, the turbine, the foundation and the sub-sea cables. These vessels are designed so they can adequately transport the part to the planned wind farm location (Damen Shipyards Group, 2019). They are however used for more wind farm or other offshore installation projects. The installation of a substation and cables commonly happens separate from installing the foundation and the turbine. The cables are usually installed in several phases.

The process of installing is a process that starts at the bottom and from there moves up, starting with the foundation followed by the turbine, which is then installed on the foundation with a transition element. To do so, the tower is first placed on the construction where after the nacelle is installed. After this only the blades are left, which can be installed one by one or all together already attached to a rotor (Lindvig, 2010). There exist ways in which this process of installing all parts one by one can be done more efficiently, installing first the foundation followed by the turbine as one piece (Boskalis, 2019).

In this part of the process, the established environmental risks should be considered and mitigated where possible. Innovation in the design of the different elements can contribute to decreasing environmental impact, for example a foundation that is connected to the sea bottom by vacuum pressure rather than being drilled in it (Van Oord, 2019). An innovation in design or installation can make a great difference on the environmental impact of an offshore wind farm.

Export: The logistics & installation phase knows several parts but for the vessel provision, export of the vessel is recommended. Not only because of the specifics and the size of the ship but also because ships are often used for more projects, so recycled in that sense.

Operation & maintenance

Operation refers to all the activities related to when the offshore wind farm starts operating. This can be market monitoring, electricity sales, administration but also remote monitoring of the turbine and environmental monitoring (GL Garrad Hassan, 2013). Maintenance is the more costly and risky part of the two. It refers to maintain and if needed repair the elements that make up the wind farm. The monitoring done during operation can indicate where and when maintenance is required (GL Garrad Hassan, 2013). Different types of farms with their own specific features demand different types of maintenance approaches. Distance, for example, decides whether maintenance can be performed from a boat or if the farm requires an offshore installation. There are three different types of maintenance: work-boat based, heli-support based and offshore-support strategies (GL Garrad Hassan, 2013). The work-boat based approach is for wind farms that are close to shore, the boats operate from port, a heli-support approach usually includes a boat supported by a helicopter and offshore-support approach refers to an offshore facility installed specifically for maintenance (GL Garrad Hassan, 2013). So to say the operation & maintenance refers to the work and maintenance needed as soon as the wind farm starts operating.

Export: This phase mainly involves local employment and the export potential lies especially in knowledge about the process.

Decommissioning & recycling

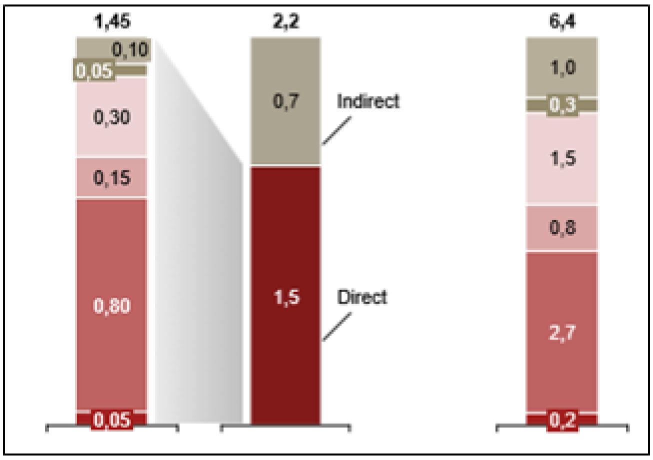
Decommissioning is a relatively new phase of the life cycle of an offshore wind farm and about four years ago the first wind farm had to be decommissioned. The importance of this phase is increasing now that more and more wind farms or individual turbines need to be decommissioned as they have come to the end of their life cycle. However, decommissioning should be considered already at the start of a project, as this might prevent problems later on. This phase of the project has received little attention and only a minimal share of knowledge has been dedicated to this topic

(Topham & McMillan, 2017). An advantage is that the knowledge and techniques that are used in decommissioning offshore oil and gas installations is very similar and can be applied in these cases as well.

The Dutch contribution

Economic implications

For the Dutch economy the offshore wind industry is already an important contributor. In 2017 the direct contribution was € 1.5 billion and the indirect contribution was € 0.7 billion together contributing € 2.2 billion (PwC, 2018a). As presented in figure 8 the largest share is from logistics & installation, followed by foundations. These two sectors are also the ones that provide most employment. Interesting to note is the relative small contribution of design & development to the direct economic contribution (0.10) compared to the high amount of FTE's (1.0 x 1000) it provides.



1.	Design & development
2.	Turbine
3.	Foundation
4.	Substations & cables
5.	Logistics & installation
6	Operation & maintenance

Figure 8: Economic (in billion euros) and employment (FTE x 1000) contribution of offshore wind industry to Dutch economy (PwC, 2018a)

The offshore wind industry is only starting to globally develop with many projects planned to be developed in the years to come and many countries only starting to explore their possibilities for development. This means that the demand will increase and opportunities for Dutch companies operating in the industry will arise. For 2030 the economic contribution to the Dutch economy is estimated at € 4 billion euros and the employment in the sector is expected to increase to 11.800 FTE (PwC, 2018a). This is however in the basis scenario, in a more expeditious scenario the value can € 6.5 billion euros in 2030 (PwC, 2018a).

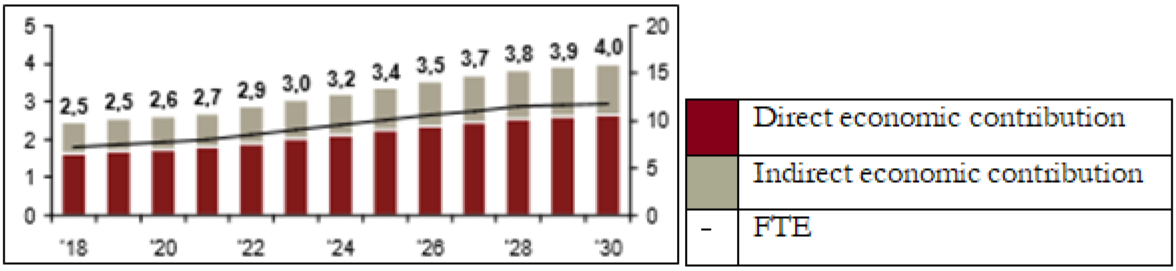


Figure 9: Expected direct and indirect economic contribution and FTE (PwC, 2018a)

Dutch strengths

From the discussed information and the data in figure 10 we can interpret that the Dutch strengths and competitive advantage are mainly concentrated in the phases of design & development, foundations and logistics and installation. This does however not mean that there are no outstanding firms operating in the other phases of project development.

Phase		**Netherlands**	**Europe**	**World**	**Market share in Europe**
	Design & development	85%	15%	2%	25-35%
	Turbines	2%	2%	0%	0-5%
	Foundations	80%	12%	5%	15-25%
	Substations & cables	10%	5%	2%	7,5-12,5%
	Logistics & installation	85%	40%	5%	60-70%
	Operation & maintenance	60%	5%	2%	0-5%
	Decommissioning & recycling	40%	10%	0%	n.a.

Figure 10: Dutch participation in different phases of offshore wind within different regions (PwC, 2018a)

The first important phase of development is doing careful research and investigation of the chosen site. Research, however, is something that happens constantly, even without specific plans for developing a farm. The industry is constantly being innovated and for that a continuous and strong R&D is needed. The Netherlands has some important research institutions that invest in project-related and non-project-related research about specifics of the offshore wind industry. An explanation for the existence and the strength of these institutions can be found in the Triple Helix model. Due to the government supporting the institutions, they can persist and continuously improve their research, resulting in innovation of the industry. However The Netherlands has leading players in all segments of the industry. Some of the most important are introduced in the table below.

Design & development

Research institution	Focus on
Deltares	Research on water, soil and subsurface
DUWIND, Technical University Delft	Research on wind turbines and offshore industry
ECN Wind Energy	Research on wind turbines
IMARES, Wageningen UR	Research on marine ecology
Maritime Research Institute Netherlands MARIN	Research on waves, tides and wind Developing wind turbine and installation vessels and offshore structures
NLR, National Aerospace Laboratory	Research on environmental policies Research on wind turbines around airports Noise reduction Research on materials and structures
DNW	Wind tunnel testing and simulation techniques Noise reduction techniques
TNO	Research on quality of materials Research of environmental impact

Design & development

Company	Description
Eneco	Eneco Group is an energy provider in the Netherlands that invests in offshore wind farm development and in the innovation of this industry.
Shell	Shell is a global leader in the offshore oil and gas industry and the use this knowledge and

	experience for the development of offshore wind farms.
TenneT	TenneT, as mentioned before, is the Dutch TSO that also operates in other Northern European countries. They invest in offshore to onshore grid connections and are constantly trying to improve and innovate this section of the industry.

Turbines

Company	Description
Lagerwey	Lagerwey is one of the few Dutch manufacturers of wind turbines with, at this moment, a maximum capacity of 4.5 MW.

Foundations

Company	Description
DOT	DOT focuses on the improvement of integrated offshore wind solutions, inter alia foundations, installation, connection and protection from corrosion.
SIF	Sif Group is a provider of offshore foundations that also due to experience in the offshore oil and gas now has a leading role in the offshore wind industry.

Substations & cables

Company	Description

TenneT	TenneT constantly tries to improve the offshore to onshore grid connection through innovation in the cables.

Logistics & installation

Company	Description
Ampelmann	Ampelmann develops movement compensation systems that make it easier and safer for people and cargo to transfer from a ship to an offshore construction.
Boskalis	Boskalis is globally known for its dredging services and other offshore infrastructure solutions.
IHC	Royal IHC, or IHC, supplies equipment and vessels for the development of offshore wind farms, mainly for dredging
Seaway Heavy Lifting	Seaway Heavy Lifting provides developers with the right, heavy lifting vessels for the installation of offshore wind farms.
Van Oord	Van Oord is a world leading company in the area of dredging and marine engineering and also operates in the development of offshore wind projects.

Operation & maintenance

Many of the mentioned companies also contribute to the operation & maintenance phase, for example by providing vessels and engineering solutions.

Decommissioning & recycling

This is a relative new phase of the project cycle and not many companies are specialized in it. However, companies that operate in the offshore oil and gas sector can apply similar techniques in the offshore wind industry.

Important to mention is that many companies operate in more than one phase of the project development. Also, this is only a selection of the Dutch companies that are active in the offshore wind industry. Many other operators and suppliers contribute to the industry, directly or indirectly. The companies and institutions mentioned above are larger and important ones that together operate together in GROW (Growth through Research, development & demonstration in Offshore Wind). Additionally, GROW has some members that have their origin in neighbouring countries. They cooperate to reach innovation and cost reduction. Many international firms have subsidiary companies located in The Netherlands as well that do also contribute to the Dutch economy and provide employment. However, for this report the focus will be on Dutch national companies.

Taiwan as the next offshore paradise

Upcoming markets

Whereas for a few decades the development of offshore wind farms was concentrated in the North West of Europe, in the last ten years the global interest in the industry has grown. Generally, global interest in reducing greenhouse gas emissions has grown as countries are more and more aware of the seriousness of global climate change. This growing awareness was transformed in a global agreement in 2015 in which 196 countries pledged to commit the years to come to a common goal: limit global warming to a maximum of 2 degrees Celsius, compared to the pre-industry level (United Nations Framework Convention on Climate Change [UNFCCC], 2016). This agreement, known as the Paris Agreement, aims to strengthen international benevolence in order to together reach a shared objective. The objectives of the agreement are, besides limiting global warming, to strengthen the resilience of countries against the consequence of climate change and to reach stable growth without increased greenhouse gas emissions (UNFCCC, 2016). Beside the agreement, all countries submitted their intended Nationally Determined Contributions (NDCs), individual long-term goals per country. These goals differ per country and so do the to be applied mitigation measures to reach these goals do so as well (UNFCCC, 2016).

A common mitigation measure in all countries is the increase of renewable energies in the national energy mix. The use of renewables will especially be of importance in the generation of electricity, as in transport and heat generation it is not yet a one on one solution. The International Energy Agency expects that almost 30% of world's electricity consumption in 2023 will come from renewable sources (IEA, 2018). For many countries wind energy will make up a considerable share of this and the offshore wind generation will play an increasingly important role in this. The global offshore wind capacity has increased from 1.4 GW in 2008 to 23.4 GW in 2018 (Statista, 2018). A strong growth, although it is only four per cent of the total 591 GW installed wind energy capacity (GWEC, 2018). This share is expected to steadily increase and in 2025 with 100 GW it should make up 10 per cent of total installed wind energy capacity (GWEC, 2018). Even though the growth will be worldwide, Europe will have a large share of the total growth and will continue to expand its offshore wind industry. Besides Europe, the USA is also seen as a growth potential. The main contribution to the growth is however expected to come from Asian countries, with an annual added installation capacity of 5 to 7 GW (GWEC, 2018). An important requirement for the realization of this growth is that governments commit to their plans by the creation of favourable policies and facilitate and support the construction process.

Taiwan

One of the Asian countries that is expected to expand its offshore wind industry in the years to come is Taiwan. It is located in the Pacific Ocean, with China on its left and the Philippines south of it. The country has a strong economy and it also known as one of the four "Asian Tigers" (Jones Day, 2018). The most important trading partners for Taiwan are China, Hong Kong, USA, Japan and Singapore (Jones Day, 2018). Taiwan has announced an ambitious plan to expand its renewable energy sector. Before discussing the country's intentions, it is important to understand the motives.

Taiwan is an interesting case as it is not a recognized sovereign country, rather a state of China. Taiwan, formerly and officially known as Republic of China, is not a sovereign member of the United Nations nor is it of the UNFCCC. For years it has tried to become a member or at least a participant at the Conference of Parties (COP), however due to China opposing this, other members are pressured to support China, being an important member. Support from other countries, like the UK, is growing more and more. The UK, for example, explains a shared goal of combatting climate change as an important shared value that demands global cooperation (Taiwanese Embassy United Kingdom, 2018). To reach these global objectives, Taiwan will be an important player. It is the world's 29th largest emitter and per capita the 7th largest emitter of CO2 and was in 2007 the number one CO2 emissions per capita in Asia (Wang, 2017). A main explanation for this is the largescale use of coal (46%) in the energy supply of the country (KPMG, 2018). The country is keen on changing this and has several reasons and motives for its decision to invest in renewable energy sources.

Besides the motivation to combat climate change, Taiwan has other internal motives for their energy mix adaptations as well. The country, surrounded by sea and with China as its closest neighbour, has historically always been extremely dependent on importing energy. More than 98% of its primary energy is imported, creating an energy dependency (Hu et al, 2016). Of this, the largest shares are made up by oil, coal and natural gas (RVO, 2015). At the same time the energy demand is quickly increasing, for several reasons. First, the country is industrializing which impacts the energy demand. Also, most people are experiencing growing welfare which leads to changed life patterns and an increased individual energy use, influencing the demand of energy as well (Hu et al., 2016). Therefore, another reason for Taiwan to invest in renewables is to decrease its energy dependency and increase its energy security.

The government has acknowledged that both top-down and a bottom-up approaches and support is required for a successful road to achieving the intended objectives. A firm top-down initiative of the government is the Greenhouse Gas Reduction and Management Act, presented in 2015 (Jones Day, 2018). In this domestic law the country presents it objectives for the decades to come. The explanation of this law on how to execute the stated targets was presented in 2017 in the National Climate Change Action Guideline (International Carbon Action Partnership, 2019). Despite not having signed the Paris Agreement, Taiwan has established its own, independent intended Nationally Determined Contribution. By 2030 the greenhouse gas emissions should be 20% below 2005 levels and by 2050 they should be 50% below 2005 levels (International Carbon Action Partnership, 2019). Important to note is that about 90% of Taiwan's greenhouse gas emissions come from fuel combustion, focus on the energy sector is therefore crucial (RVO, 2015). In 2025, 20% of its electricity will be generated from renewable sources and in 2030 this should be increased to 26% of its total power generation also in 2025, 50% of its electricity use should come from natural gas (Hu, Lin, Fan, Lien & Chung, 2016). The approach to reach this goal differs from the other countries in the region, as many neighbouring countries do focus on nuclear as a replacing source of energy, whereas Taiwan does not want nuclear to be part of the solution and wants a nuclear-free country by 2025 (Hu et al., 2016). The Taiwanese people voted in favour of nuclear power and wanted to maintain the nuclear power plants, but the government decided otherwise and they are now starting to phase out the few active nuclear stations that are left in the country (World Nuclear News, 2019). Instead the country focuses more on the inclusion of other types of renewables, mainly solar and (offshore) wind (Hu et al., 2016).

The target to generate 20% of its energy from renewable sources in 2025 indicates an approximate 27 GW should come from other sources than fuel and nuclear ones. The largest share will come from solar PV with a planned 20 GW in 2025. However, the offshore wind industry will also make a large contribution to this, with a planned 5.5 GW to be installed (KPMG, 2018). Of this capacity, 3.5 GW should be operational in 2020 and 2 GW more before 2025 (Wang, 2017). Besides solar PV and offshore wind, hydraulic, onshore wind and biomass will make up another 1.5 GW (Jones Day, 2018).

This report will focus on the development of the planned 5.5 GW offshore wind farms. Not only does Taiwan offer benevolent policies, a supporting government and ambitious targets, the country's circumstances and geographical conditions are favourable as well. First of all Taiwan is an island, surrounded by sea and with the main urbanization found in coastal areas, as visible in figure 11. Like mentioned before, offshore wind farms offer a solution for the intensifying urbanization and growing population in general, if this takes place near shore. The short distance between the offshore generation and the onshore consumers enables the decreased transmission distance, saving on the generally high transmission costs and providing an overall saving on the energy price.

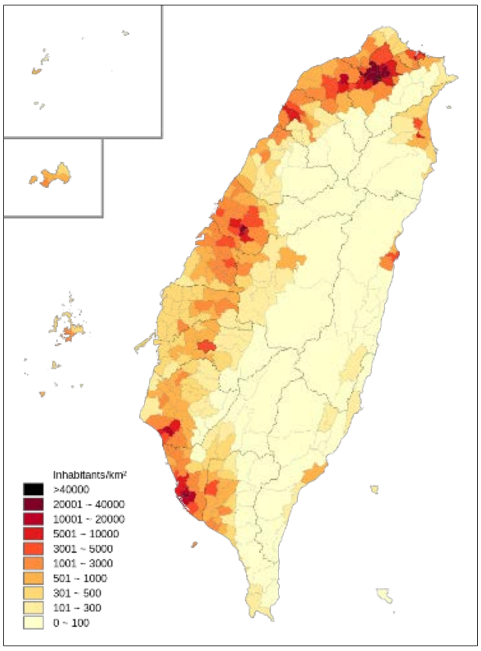


Figure 11: Population density Taiwan in 2011 (Ministry of the Interior, 2011)

Favourable conditions

The island is located in the Western Pacific and has the Taiwan Strait on the left, which is an area with great potential for offshore wind development. It is the part that separates the island from China and has a length of 300 km and a width of 180 km. A side note is that the weather in the area is rather volatile, with sometimes strong waves, typhoons and monsoons (Tseng, Lee & Liao, 2017). The west coast of Taiwan, or the Strait, at about 100 meters from coast, knows wind speeds of about 9 – 12 meter/second (Chang, Yang & Lai, 2015). This speed is extremely favourable for generating wind energy. Also the wind speeds around Taiwan are strong and stable, with about on average 2500 full load hours. This refers to the hours per year that the wind speed is high enough (10 m/second) for the turbine to generate at its full capacity. The amount of full load hours is higher in Taiwan than in the existing European wind farm sites (RVO, 2015). With the existing wind turbine sizes and techniques, the average capacity factor of the installed (demo) turbines was

29%, with in some places capacity factors of about 50% (RVO, 2015). This is considerably high, when considering that in Germany this is around 20% (RVO, 2015). The area around the Taiwan Strait has an estimated potential of at least 6 – 10 GW, estimated with the knowledge and techniques existing in 2015 (RVO, 2015). However, just like the case with offshore oil and gas reserves, the potential will increase as techniques develop. The Taiwanese Bureau of Energy (BoE) is in favour of the plans to develop the offshore wind industry and confirm the great potential of the Taiwan Strait, as presented in figure 12 (Asia Pacific Economic Cooperation [APEC], 2014).

For a feasible offshore wind farms, not only the wind conditions, yet also the sea and seabed conditions are influencing factors. As presented in figure 13, there is a difference between the potential of the area and he feasibility. The difference between these two can be explained by several reasons, such as depth of the water, sea bed conditions, wave climate and distance to shore, however all can be improved or solved with innovation in the techniques used in the offshore industry (APEC, 2014). Despite the difference between potential and feasible capacity, Taiwan has favourable natural sea conditions for the construction of offshore wind farms.

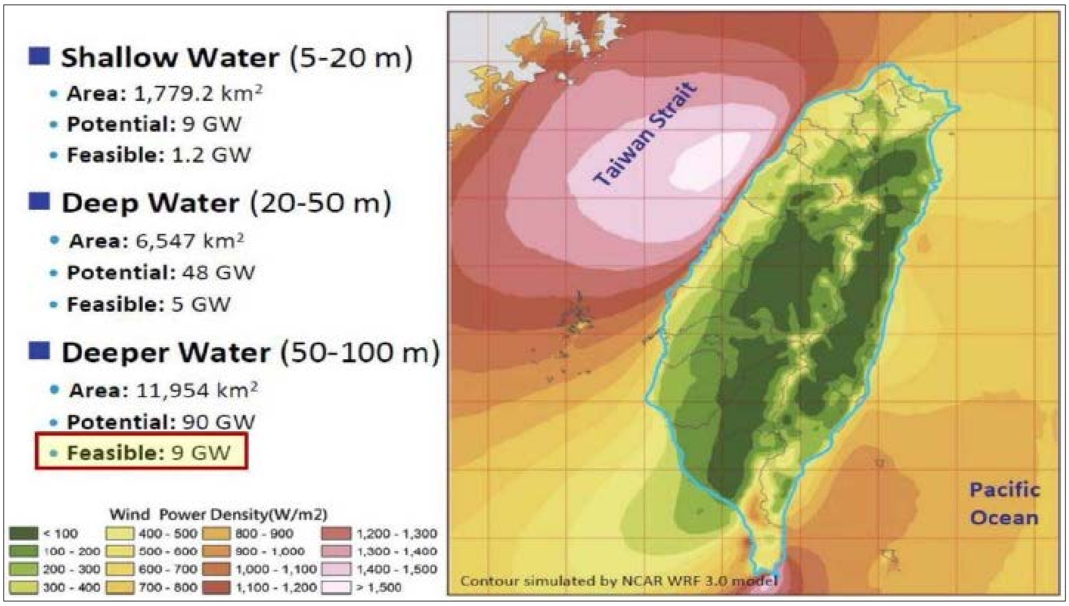


Figure 12: The potential of the waters surrounding Taiwan (APEC, 2014)

Favourable government support

With the motivation to become self-sufficient and decrease its dependency, already in 2012 the government demonstrated its supportiveness of the development of an offshore wind industry. It presented the Thousand Wind Turbines Project in which the government announced it strategy for the development, starting with a small-scale pilot and developing in the 1000 wind turbines (both on- and offshore) before 2030 (RVO, 2015). The first phase, the pilot phase, consisted of the intention to install three demonstration wind farms before 2020, which could receive government's subsidy and materials to be constructed (Bureau of Energy, 2019). The first of the demonstration farms is the Formosa 1 farm that was established at the end of 2017. Together with a project called Fuhai, Formosa 1 is a private-led project. Formosa 1 has a capacity of 128 MW, Fuhai of 120 MW and the state-owned project called Taipower will have a capacity of 110 MW (Yeap, Wang & Harris, 2019). After this first demonstration phase, in July 2015 the government announced during the second phase that there would be 36 zones, mainly near the Taiwan Strait, that would be open for offshore development (Yeap, Wang & Harris, 2019). Later, in 2018, the government clarified its objectives and how and when they were to be achieved. The first 0.5 GW is to be completed in 2020, then 3 GW by 2025 through a selection procedure and the other 2 GW by 2025 but through a competitive bidding procedure.

There are thus two ways in which the permission to develop capacity can be awarded. The first is a selection based on certain criteria and the second is a bidding competition. The Taiwanese Ministry of Economic Affairs (MOEA) started allocating capacity to several participants in April 2018, as presented in the following table (Yeap, Wang & Harris, 2019):

To be completed by 2020			
	Company	**Origin**	**Capacity**
	Wpd Taiwan Energy Co Ltd (Wpd)	Taiwan	360 MW
	Swancor Holding Co Ltd (Swancor)	Taiwan	378 MW
To be completed between 2021 and 2025			
	Company	**Origin**	**Capacity**
	Wpd	Germany	698 MW
Split into two projects	Ørsted	Denmark	900 MW
Split into two projects	Copenhagen Infrastructure Fund (CIP)	Denmark	600 MW

	China Steel Corporation	China	300 MW
	Taipower	Taiwan	300 MW
	Northland Power & YuShan Energy	Canada & Taiwan	300 MW
		Total capacity	3836 MW

The other manner used to allocate capacity is the competitive bidding. Whereas in the selection based manner there were some requirements like local participation, in this round the decisive factor was the accepted tariff. The bidding round was held in June 2018 and the following companies participated: Northland Power and YuShan Energy, Swancor and Macquarie, Ørsted, CIP and Taipower (Yeap, Wang & Harris, 2019). After this bidding round, Northland Power & YuShan Energy and Ørsted both won two projects with the following price and capacity (Yeap, Wang & Harris, 2019):

Bidder	**Project**	**Price**	**Capacity**
Ørsted	Greater Changhua South-West	NT$2.5480 (+/- US$0.0828) per kWh	337.1 MW
	Greater Changhua South-West	NT$2.5481 (+/- US$0.0828) per kWh	582.9 MW
Northland Power & YuShan Energy	HaiLong no. 2	NT$2.2245 (+/- US$0.0723) per kWh	232 MW
	HaiLong no. 3	NT$2.5025 (+/- US$0.0813) per kWh	512 MW
		Total capacity	1664 MW

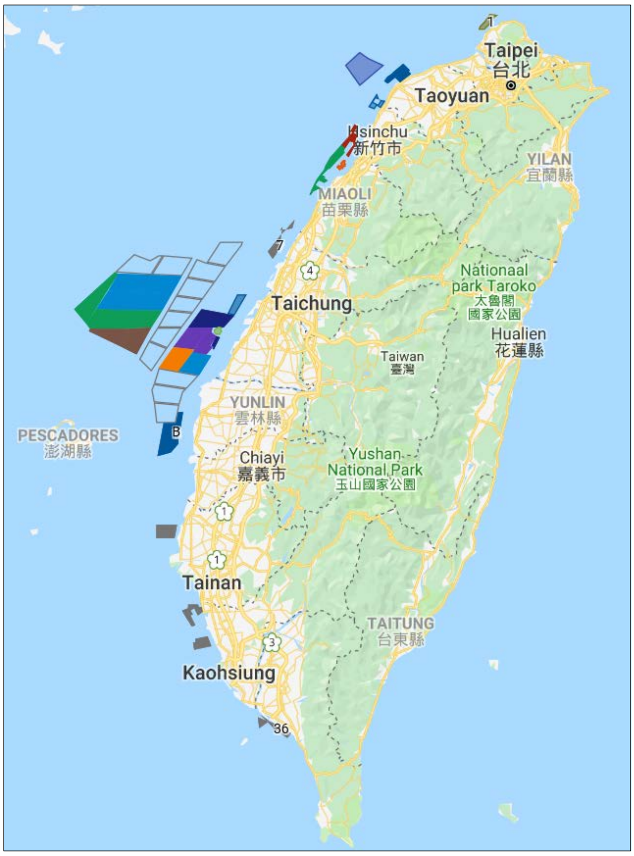


Figure 23: Current status of Taiwan's offshore wind power territory (Eiger, 2019)

The combined capacity of the selective round (3836 MW) and the competitive bidding (1664 MW) make a total of 5.5 GW, which was allocated in 2018.

Before the awarded offshore capacity can be developed, all developers have to obtain an Environmental Impact Assessment (EIA). In Taiwan, this means that the developer has to submit an environmental impact statement (EIS) to the MOEA, who will forward it to the Environmental Protection Administration (EPA) (Chao, Wang, Brughmans & Kuo, 2018). The EPA is the responsible organ for assessing the submitted statement and who will provide a preliminary approval that might demand for some adaptions in the project (Chao et al., 2018). After these have been applied, the submission will be revised and a final approval will be given and, after a public meeting, the EIA will be approved (Chao et al., 2018). Taiwan also knows the not so common second phase EIA, a more extensive and strict phase for sensitive projects (Chao et al., 2018). So far, offshore wind projects have not been subject to this second phase EIA. A more detailed description of the process of project implementation is presented in figure 14.

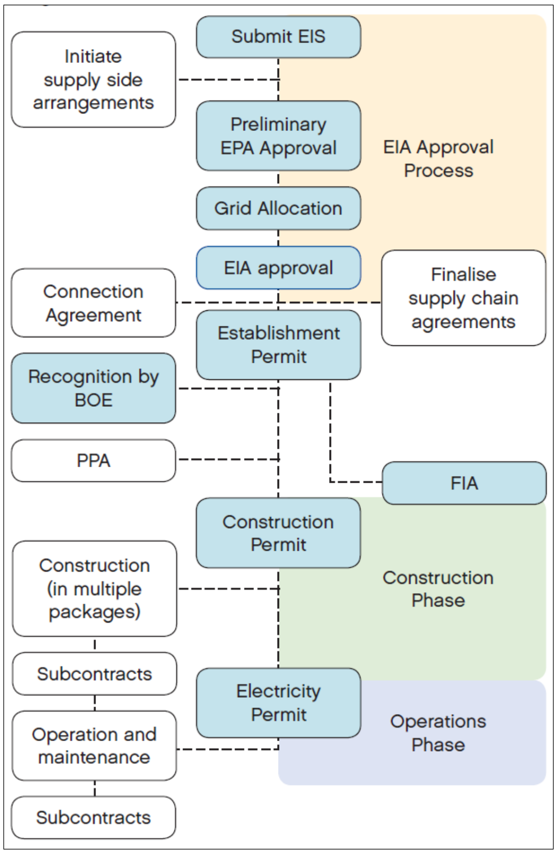


Figure 14: Process of project implementation (Jones Day, 2018)

The next step or the third phase is the actual development of the farms and of the industry, which will start this year in 2019. The allocated territory will be divided so the companies and bidders can start developing the actual project. Also, the government of Taiwan has announced that it will start developing its local supply chain, in as many aspects of the different phases of development as possible, to create a sustainable and local industry (Yeap, Wang, Harris, 2019). This could provide opportunities for knowledge and experience sharing from companies from other countries.

The Taiwanese government will support the development of the industry with a Feed-in-Tariff (FiT) for the first twenty years. The initial announcement made in 2018 by the government was that the FiT would be NT$ 5.8498/kWh (US$ 0.1895/kWh) (Yeap, Wang, Harris, 2019). To be eligible for the FiT, there were the requirements to have obtained a so called Establishment Permit for the construction as well as a Power Purchase Agreement (PPA) with Taipower before the ending of 2018 (Yeap, Wang, Harris, 2019). In the beginning of 2019, however, it turned out that four sponsors with a total of six of the planned projects were not able to obtain one of the requirements of the Establishment Permit, namely the permission of the local government of the area of construction (Yeap, Wang, Harris, 2019). In the case of those four developers, the projects are to be developed in the Changhua area. The Taiwanese Ministry of Economic Affairs reconsidered the requirements and came with a new proposal for 2019: a PPA with a tariff of NT$ 6.2795/kWh (US$ 0.2036/kWh) for the first ten years and NT$ 4.1422/kWh (US$ 0.1343/kWh) for the following ten years, making it an average of NT$ 5.5160/kWh (US$ 0.1788/kWh) (Yeap, Wang, Harris, 2019). The change indicates that the new proposed tariff for the PPA's is 5.7% lower than initially announced in 2018. This caused a lot of negative reactions, not only from the selected developers but also analysts that critique the change in FiT as being an attack on the trustworthiness of future plans. For developers of renewable energy projects, stability is crucial to make a risk-free long-term investment. Instability will scare investors and will negatively influence development plans.

Challenges

Before focusing on the opportunities that Taiwan offers for the Dutch offshore industry, some challenges will be discussed.

Political instability

The mentioned change that took place in the FiT represents one of the challenges for the Dutch when they start investing in or exporting to Taiwan. It represents the possibility of financial instability which is crucial for foreign investors. Some argue that foreign investors were seduced by the plans to install 5.5 GW with an attractive FiT to such an extent that influencing political factors were forgotten (Fernandez, 2019). This financial risk was namely caused by political decisions and it turns out that political instability causes challenges for investing in the offshore wind industry. The Taiwanese government explained the changes in the FiT by wrong calculations as the Ministry of Economic Affairs had not considered the improvements in techniques and the overall reduced LCoE that will take place the next decades (Richard, 2019). However, independent of the explanation, instability is instability. The political instability that reflects on the possible financial instability is not the only form of political instability. Taiwan finds itself in a vulnerable position due to its status and relationship with China. Taiwan has been practically independent since 1950 but China does not recognize this and claims Taiwan as being part of the country (BBC, 2019). This leads to political tension and a so called diplomatic isolation, for example in the mentioned absence of support for Taiwan as a member of the UNFCCC or the UN in general. Despite the diplomatic isolation, Taiwan does relatively well when speaking about its economy and overall innovation in the country. The challenge for Dutch export to the country would therefor mainly be to analyze the political situation and take this into consideration when doing business.

Environmental impact

Another challenge that might form an obstacle for Dutch or other foreign companies that start operating in Taiwan is the inclusion of environmental consideration in the law and policies. Due to Taiwan being new to the offshore wind and the offshore industry in general, these are yet to be assessed considerations. Taiwan is known for its strict environmental laws that reflect in a strict required EIA. In many or most other countries, the EIA is one of the many requirements for a project to be approved, whereas in Taiwan the EIA on its own can be the deciding factor for the rejection of an entire project (Ming-Zhi, 2018). Another difference is that in EU countries, all to be assessed elements are explained by them forming a possible risk for the developer, whereas in Taiwan some elements are added, such as, the obtained carbon reduction, which make the execution of an EIA for developers relatively expensive (Ming-Zhi, 2018). Another aspect of the current assessment procedure that increases costs is that the different elements are scattered. Different elements require assessments from different organizations. Tseng, Lee, and Liao (2017) suggest that there is a need for an integrated assessment framework, as it would positively influence transaction costs and the time between assessing and start of development. The authors propose that rather than separate assessments of environmental, health and safety impacts, Taiwan should consider an integrated approach (Tseng, Lee & Liao, 2017). This would be beneficial for developers and would take away an obstacle for foreign developers.

Not only the efficiency of the EIA should be reconsidered to resolve a challenge for foreign developers, also the specific details for developing offshore should be looked at in the EIA. As Taiwan is new to the industry and as a country has no specific experience in the offshore sector, there are some new factors that will need to be considered in the EIA. Examples of these specific factors for the offshore wind industry are the impact on migrating birds, on ocean mammals, local fishery as well as the impact of harbor development. As the Taiwan Strait is one with a lot of traffic and biodiversity, this is an important part of the EIA (Chao et al., 2018). As mentioned, Taiwan does have strict environmental laws that protect both this biodiversity as well as for example the fishermen that might be impacted by the development of an offshore wind farm. However the weight that is therefore attached to the EIA, might create a difficult process for foreign developers.

Local climate conditions

As mentioned, the coast and specifically the Northwestern coast of Taiwan deals with strong wind speeds and seasonal typhoons and monsoons. Also the region knows a humid climate with high temperatures (Wang, 2017). These local environment and weather conditions create a challenge for offshore wind developers, especially for those operating in such conditions for the first time. It requires an adapted turbine design that is resistant to these kinds of environmental conditions. Also the foundation design needs to be adapted to local circumstances and other types of nature violence such as earthquakes (Hu, 2017). These specific conditions for local development create technology gaps that can be filled with adequate R&D and adapted design.

Local participation

As in most cases, the Taiwanese government does demand the participation of local companies in the development of the offshore projects. The motive for a government to demand this is to encourage the local industry to develop. Rather than inviting and paying foreign companies to develop the desired projects without any form of knowledge transfer, the government aims for foreign companies to cooperate with national companies to develop and strengthen its own industry (Chao et al., 2018). However if for example there is a underdeveloped local industry or shortcomings in the infrastructure and a government does demand local participation in that specific part of the supply chain, costs will rise and therewith the LCoE will increase. Not only might this be a challenge for foreign developers, it might also be a challenge for the country itself. Establishing a local supply chain in a country with little to no experience demands a clear strategy and high investment costs.

A successful knowledge transfer will give Taiwan a new asset to strengthen its knowledge-based economy. As Rosenberg (1976) implicated, increased knowledge in a country will positively contribute to the well-being of the country. In the case of Taiwan this might imply that it will, after the knowledge transfer, has developed a national industry that will be useful for the maintenance of existing and development of new offshore wind farms. It might however also mean that it is creating the base for a new export asset, for example to other Asian countries. The government demands the following:

Figure 15: Required local participation (Chao et al., 2018)

The required local participation is not necessarily a challenge, yet it is a criterion that needs to be considered. Also when compared to other countries that are developing their offshore wind industry and that offer a perspective with potential, Taiwan demands relatively little local participation and is considered open for foreign participation.

A specific challenge within the required local participation is that of finding the right local partner. Dutch companies, for example, are willing to transfer knowledge on turbine blades, equipment or supportive vessels, however the Taiwanese counterpart is not always able to invest in these (C. Chang, personal communication, June 3, 2019). This creates the problem of fulfilling the requirement of cooperating with Taiwanese counterparts. At the same time, if the Taiwanese regulation allows it, this could create opportunities for knowledge transfer between Dutch or other foreign companies and Taiwanese companies (K. Mokveld, personal communication, June 18, 2019). For current project developers this is however still a challenge.

Logistics and distribution

In the different phases of the project development, different sorts of logistics and distribution are important. For the initial phases the transport of heavy components by vessel is required and for this a well-developed port is necessary. Countries that have no previous experience in offshore development, be it wind be it fossil fuel extraction, do generally not have the adequate port characteristics. Taiwan therefore is focusing on the improvement and adaption of existing ports, such as the Taichung Port (Russell, 2019). Even though it being the second largest port of the country, it is strategically the most important as it is located near the Taiwan Strait (Russell, 2019). The role of this port for the offshore wind farms will be a location for the production of, storage for and assembly of components as well as transport of components from the island to the development site (Russell, 2019).

Besides this part, the actual logistics of vessel coordination forms an experience gap in Taiwan as well (Hu, 2017). This results in weak marine policy and regulation that complicates the development of wind farms. A reflection of this is found in the local content requirement of vessels and the blockage of vessels from China (C. Chang, personal communication, June 3, 2019). This creates a shortages of certain vessels and a monopoly for the few owners of the right vessels, which again results in higher overall project development prices (C. Chang, personal communication, June 3, 2019). As for port development, the UK has recently signed a Memorandum of Understanding for the support of the port development, however with the increasing capacity the port might go through several developing stages. As for distribution, the challenge will arise in a later stage of the project. Challenges are appropriate energy storage of the offshore generated energy, the right connection to the (smart) grid and the coordination between the different developers, stimulating efficiency (KPMG, 2018). Port development and management, vessel regulation, energy storage and grid connection are thus areas of attention for Taiwan.

Opportunities

Up until this point the existing and expected political instability has not yet scared foreign investors and developers. In the Global Offshore Wind Summit last April, leading companies announced their continued trust in the government of Taiwan and their desire to continue developing (European Chamber of Commerce Taiwan [ECCT], 2019). Instead they proposed how experience in regulation in one country could be transferred to Taiwan, creating opportunities for foreign experienced markets (ECCT, 2019). The challenges for one country can thus be solved with the experience and the know-how of another country. Therefore, the challenges that Taiwan is facing in developing its offshore wind industry in combination with the promising plans for capacity development, create opportunities for foreign project developers. In this case the first mover advantage applies partially, as a developer that has been awarded territory to develop capacity is handed the chance to gain trust of Taiwan and might enjoy the advantage of this in a future tender. However, as explained, the majority of the capacity was awarded through the competitive bidding tender. In this case, a developer needs to prove its competitive advantage by being able to deliver a certain capacity for a certain pre-established price, requiring certain levels of innovation and efficiency. Also, as Taiwan is aiming for strengthening its own industry, it will focus on several partners with expertise in different phases of the value chain. And as this local value chain is yet to arise and evolve under the supportive policies of the government, opportunities occur in all phases. For example to develop a local supply chain, Taiwan should focus on international cooperation. Innovation and technological improvements happen regularly and for the industry to develop and remain up to date, international cooperation with frontrunners will establish a sustainable industry. In Taiwan in all phases of development and of the supply chain opportunities to participate or export exist for foreign developers and suppliers.

Major players in Taiwan

When developing an export strategy and export plans it is important to understand the local situation and be aware of the local major players. Even though the industry is constantly developing new relevant institutions and new players are joining, the current players have been identified. The following were found to be the most important national players in the initial phases of development (RVO, 2015):

Important government agencies	
Bureau of Energy (BoE), Ministry of Economic Affairs (MOEA)	Assists demonstration projects and project developers e.g. with the EIS
Industrial Development Bureau (IDB), MOEA	Establishes policies for energy and offshore wind industry
Department of Industrial Technology (DoIT), MOEA	Stimulates local technological development through Triple Helix model
Bureau of Standards, Metrology and Inspections (BSMI), MOEA	Verifies standards, metrology and product inspection

Major wind farm developers	
Taiwan Power Company (Taipower)	State-owned power company (MOEA), joined demonstration program under government subsidies (108 MW by 2020)
Taiwan Generations Corp. (TGC)	Strong R&D, cooperates with foreign companies to develop Fuhai Deployment Zone (120 MW)
Formosa Wind Power Company	Led by Swancor Corp (Formosa 1 - 128 MW, Formosa 2 - 378 MW, Formosa 3 - 1,9 GW)
Important R&D institutes, industrial associations and companies	
The Green Energy and Environment Research Laboratories (ITRI)	R&D, feasibility studies, EIA, design evaluation
Taiwan Wind Energy Association	Develop technologies for Taiwan's wind energy industry
Taiwan Wind Turbine Industry Association (TWTIA) C/O: Metal Industries Research Development Center	Institute to connect industry, academia and research institutions
China Steel	Developing foundations and substructures
Siemens Limited Taiwan	Cooperate with Formosa Wind Power and Taiwan Generations Corp. in building offshore wind farms in Taiwan

Teco Electric and Machinery Co. Ltd	Pioneer in the local wind turbine motor development

Planning

For successful participation in opportunities timing can be crucial. Therefore policies, project plans and schedules should be considered when focusing on opportunities. The planned 5.5 GW that is divided over various projects are currently in different phases of development. All farms should be finished and operating by 2025 with the different phases of construction presented in figure 16:

Year	Works
2021–2022	• Investigation and exploration • Cable laying • Ship and equipment design • Safety management • Ship construction
2023	• Wind turbine components production • Submarine cable laying • Tower and submarine foundation construction • Ship and equipment design • Safety management • Ship construction • Other uncompleted plan and preparation work
2024–2025	• Wind turbine components production • Wind turbine construction • Ship and equipment design • Safety management • Other uncompleted Phase 1 work

Figure 16: Expected development of projects (Industrial Development Bureau, 2018)

As the planning in the figure shows, in the years to come various opportunities for cooperation will emerge as project developers start subcontracting elements of the supply and installation chain. Dutch companies operating in the sector should therefore be proactive to benefit from and participate in the procurement process of the project developers.

Also in April 2019 the BoE, working under as a bureau of the Taiwanese MOEA, announced that the government is planning another phase for the offshore wind development of which more information will follow later this year (REVE, 2019). The BoE already shared the plan to develop another 5 GW of offshore wind capacity that should be operating between 2026 and 2030 (REVE, 2019). As with the initial 5.5 GW, the development will be open for foreign developers. Exact details, for example about location, subsidies, PPAs or FiT will be announced at the end of this year.

The Netherlands and Taiwan

Individual participation

The different parties involved in the Dutch offshore wind industry have not left the developments in Taiwan unnoticed. Various activities, trade missions and business to business (b2b) contacts have taken place in the past years. Even though there is no Dutch consortium that won or participated in an auction in Taiwan, there has already been made an entrée into the market by a few Dutch companies. In 2017 Sif, a Dutch offshore foundation manufacturer signed a letter of intent with Century Wind Power Co. (Taiwan) to explore the possibilities of cooperation (Russell, 2017). However, this same Taiwanese company in 2018 established a joint venture with Bladt Industries (Denmark) for the supply of jacket foundations and transition pieces (Offshorewind.biz, 2018). Also the Dutch consultancy company BLIX Consultancy has indirectly participated in the Taiwanese developments as it was part of the auction preparations of the consortium Northland Power and Yushan Energy, who were awarded a joined capacity of 744 MW (Blix Consultancy BV, 2018). In 2018 Van Oord, a Dutch dredging and offshore operator, was chosen as a preferred contractor by the German wpd for the large 640 MW Yunlin project. Van Oord will focus on the designing, manufacturing as well as installing the eighty foundations of the offshore wind farm (Van Oord, 2018). Another important Dutch player in the offshore industry who is participating as of this year in Taiwan is Damen Shipyards. The Taiwanese Hung Hua Construction Co. Ltd. (HHC) ordered two large crew supply vessels that should be delivered in the beginning of next year (Damen Shipyards Group, 2019). HHC is the largest dredging and offshore (near shore) construction company of Taiwan and is cooperating with the Taiwan Power Company (Damen Shipyards Group, 2019).

Joined participation

Already in 2016, the Dutch export wind energy association, Holland Home of Wind Energy (HHWE) signed a Memorandum of Understanding (MoU) with the Taiwan Wind Turbine Industry Association (TWTIA) (HHWE, 2016b). The MoU is a representation of the desire from both countries to start working together in the field of offshore wind energy. Although not binding, it is a formal way for countries to express interest in cooperation.

Several trade missions to Taiwan have been organized and a few of them were organized around the offshore wind sector. Although it was not the first, in 2016 and in 2018 HHWE organized outgoing missions and in 2017 an incoming mission, both with the motive to encourage the export of the Dutch offshore wind industry to Taiwan. HHWE organized these missions together with the Netherlands Trade & Investment Office (NTIO) in Taiwan and the Netherlands Enterprise Agency (RVO). For the outgoing mission in 2016, a special invite was send to those companies operating in the phases of installation and operation & maintenance of developing offshore wind farms (HHWE, 2016). The mission offered all kind of activities concerning the Taiwanese offshore wind industry, company visits, site visits, research center visits as well as meetings with the Bureau of Energy (BoE) and the TWTIA. In 2016 the following Dutch companies joined the outgoing mission: Acta Marine, Ampelmann, Bayards, Blue H Engineering, Boskalis/SMIT Singapore, Damen Shipyards, ECN, Enersea, GustoMSC, Huisman Equipment, IHC IQIP, LM Wind Power, Mecal IX, MPI Offshore, Seaway Heavy Lifting, Trelleborg Ridderkerk and Wind Minds (HHWE, 2016). In 2017 a delegation of the Taiwan offshore wind sector was received in The Netherlands, with participants from TWTIA, Industrial Development Bank (IDB) and Chinese International Economic Cooperation Association (CIECA) (HHWE, 2017). Another outgoing mission took place in 2018, again organized by HHWE, RVO and NTIO (HHWE, 2018b). This time, there were more individual programs, tailor-made meetings for companies working in different segments of the supply chain (HHWE, 2018b). There have thus been undertaken public-private missions, both outgoing and incoming, to promote the Dutch industry in Taiwan.

Partners for International Business Taiwan

The Netherlands Ministry of Foreign Affairs (MFA) uses economic diplomacy as an asset to facilitate the entrance for Dutch companies is economic diplomacy. The use of economic diplomacy can not only help settled companies in foreign countries, it also open doors to new industries and new markets. Another way in which the government supports the export of Dutch industries is through financing programs like Partners for International Business (PIB). PIB is an example of a public-private partnership between the ministries, the RVO, which serves as the executive organ of the Ministries of Economic Affairs and Climate (MEAC), and private partners, depending on the sector. PIB is a program of the RVO and is an example of how the forces of public (government) parties and private (industry) parties can be combined to stimulate the export of an industry of The Netherlands. The rationale is that working together, with the forces of the Triple Helix, the penetration of a foreign market will be facilitated. PIB is used when a market is considered as having the potential for successful Dutch export opportunities. The offshore wind market in Taiwan was detected as such a market and in April 2018 a PIB was requested and in June 2018 it was approved. A few of the companies that joined the application are: CAPE Holland, GustoMSC, Huisman, Independent eXperts, MME Group, Sif Group, Tideway, TNO, Trelleborg Ridderkerk, Wind Minds. Furthermore IHC IQIP, Eemshaven and TKI Wind op Zee joined as strategic partners (HHWE, 2018). The companies who joined the PIB operate in various parts of the development process:

Focus	**Names**
Engineering and advisory services	GustoMSC, Independent eXperts and Wind Minds
Manufacturers of hardware, components and handling systems	CAPE Holland, MME Group, Sif Group, Trelleborg Ridderkerk, Tideway, Huisman Equipment and IHC IQIP
Knowledge institutions	TNO and TKI Wind op Zee (knowledge broker)

The PIB has as a main goal to achieve a sustainable and substantial position in the foreign market industry, in this case the offshore wind industry in Taiwan. This is achieved by a consortium of public and private partners that will receive support through, inter alia, economic diplomacy, market research and a local liaison officer in Taipei (HHWE, 2018). The PIB is thus a public-private cooperation for the promotion of export of an industry in which the Netherlands has a competitive advantage due to its continuous cooperation and focus on innovation in the industry. In the case of Taiwan it supports Holland Branding in the industry, as operating as a joined force will show the Dutch expertise in a more compact way. Also the PIB supports the joined participation in trade fairs and helps the transfer of updates on local market updates to Dutch parties. The PIB is planned by establishing several objectives and the strategic activities that will help to achieve those objectives (K. Mokveld, personal communication, June 18, 2019). This shared agenda helps the different parties to use a more focused approach. On a more critical note, the PIB only has a selection of partners that might be better of working with other Dutch partners in Taiwan as well (C. Chang, personal communication, June 3, 2019). Also, the different partners operate in different phases of export or development, which makes it harder for the joined PIB to support all partners the right way (C. Chang, personal communication, June 3, 2019). The activities of PIB in Taiwan might, in some cases, be conflicting for other Dutch companies in the industry, who are not part of PIB.

Future outlook

Beside the individual presence of Dutch companies in the Taiwanese offshore wind sector, the organized trade missions and the PIB, there are more plans for exporting the Dutch offshore wind experience and expertise to Taiwan. With the existing project developers moving to the procurement process and the announcement that new tenders will be held soon, opportunities arise. To establish a future outlook, various parties involved have been interviewed.

First, the Dutch representation in Taiwan, the Netherlands Trade & Investment Office, expresses the importance of local presence. For any activity that Dutch companies want to perform in Taiwan, physical presence and company representation in the country is important. As Taiwan has liberal offshore wind plans, other foreign leading companies show interest and invest in expanding to Taiwan as well (C. Chang, personal communication, June 3, 2019).

Besides Van Oord, Boskalis and Seaway Heavy Lifting who already got assigned projects in Taiwan, other Dutch companies can find opportunities in the supply chain as well. According to Chang there are many segments of the supply chain to which Dutch companies can contribute. Dutch expertise is found in vessel provision, turbine, foundation transport and installation, cable laying, operation & management and manufacturing hardware and other components (C. Chang, personal communication, June 3, 2019). At the same time, Dutch knowledge institutes possess knowledge and capabilities to perform necessary research and testing. According to Chang, these institutions will encounter opportunities in Taiwan as well. A concrete example for Dutch knowledge can be cooperating with the Metal Industries Research & Development Centre (MIRDC) in Taiwan (C. Chang, personal communication, June 3, 2019). They are responsible for the marine technology industrial innovation centre and, for offshore wind development, will develop their marine technology and crew training. In this specific element, Dutch expertise can be transferred through cooperation between a Dutch research or knowledge institution and the MIRDC. Also, for the government there is a role in knowledge transfer about regulating the industry and establishing policies that support the development of the sector and, at the same time, are reliable for investors (K. Mokveld, personal communication, June 18, 2019).

When planning the future of the PIB for the offshore wind industry in Taiwan, it is important that the interests of all Dutch companies are considered, not only the partners in PIB. Close cooperation is necessary to operate as one Dutch industry. This means the elements of the Triple Helix should continue operating as one, to promote Dutch offshore expertise. However, observed is that this might not always be equally beneficial for all parties (C. Chang, personal communication, June 3, 2019). PIB, as an example of Triple Helix in practice, seems to be especially beneficial for smaller companies or companies that are a second or third tier contributor in the value chain (C. Chang, personal communication, June 3, 2019). the other hand, it does create opportunities for research institutions like ECN and TKI Wind Op Zee to offer Dutch solutions to problems researched by them (C. Chang, personal communication, June 3, 2019).

For the near future, Dutch companies and consortia need to be prepared to act when the details of the expansion plans will be announced, at the end of this year. These plans will create opportunities for larger companies like Shell or a consortia of some to develop offshore wind farms in Taiwan after 2025.

Conclusion

Export is crucial for the Dutch economy and within the Ministry of Foreign Affairs (MFA) the Department of International Enterprises (DIO) is responsible for stimulating sustainable trade development. As the Sustainable Development Goals (SDGs) are a leading theme for the work of the department, supporting the export of the Dutch offshore wind is a focus task of DIO. The report has shown the government can, for example through economic diplomacy, support the export of a renewable energy industry.

The Netherlands has a relatively long history with wind mills and with offshore wind farms. Only recently the government and the industry started exploring the possibilities to export the knowledge and experience that they have developed throughout the years. The government, the industry and research institutions work together, as Triple Helix, to detect and benefit from the export opportunities that arise in foreign markets. An opportunity in this specific industry is often created by increased demand due to the government's creation of renewable energy policies.

For the exporting country both internal and external factors are important for a successful export. Internal factors are for example policies to stimulate export, incentives to innovate industry and financial support to develop a knowledge advantage. External factors are, in the importing country, for example motives to develop a renewable energy industry and policies that support this development.

The Dutch offshore wind industry has benefitted from government policies that supported its development and currently supports the export of it. Government bodies such as the MFA and Dutch Enterprise Agency (RVO) have an important role in stimulating the export of the industry. Through public-private cooperation, organizing trade missions, subsidies and overall economic diplomacy they open doors and opportunities in foreign markets such as Taiwan. At the same time Taiwan has favourable renewable energy plans and policies that require the contribution of foreign expertise and experience. Export of knowledge or specific know-how will depend on the right match-making, for which it is important to determine the major players in both markets. The report has focused on the analysis of the specifics of and major players in both markets. When combining this information with the policies and plans in Taiwan and the export strategy of The Netherlands, a comparison of demand and supply can be made.

The analysis of the Dutch and Taiwanese industries allows for opportunities to be detected and matches to be made. The current status and future outlook enable the creation of a strategy to further support the export of the Dutch offshore wind industry to Taiwan. However, a more specific approach might lead to more concrete matchmaking. When a specific offshore wind project and the involved developers are analysed, a practical recommendation and plan of action can be made. Also, for a more complete future outlook, the input of companies operating in the sector should be incorporated. This report has a more generic analysis that demonstrates how concepts like the Triple Helix and economic diplomacy apply to and support the export developments of the Dutch offshore wind industry to Taiwan.

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Appendix

1. Interview: Cindy Chang, Economic Advisor, Department of Economic Affairs, Netherlands Trade & Investment Office Taiwan, 3 June 2019

1. *Where do you think the chances for the Dutch companies will be (in what part of the supply chain) in the offshore wind sector (OWS) developments in Taiwan in the years to come?*

Taiwan is open for cooperation with international companies, including Netherlands especially for its marine engineering and offshore wind installation. Along with fast- growing development in last few years, it becomes more clear that the offshore wind farm developers are led by global companies such as Orsted, CIP, Northland Power and WpD etc. in Taiwan, consequently the major EPCI or T&I contractors well known in Europe such as Jan de Nul, DEME group, Van Oord, Boskalis and Seaway Heavy Lifting are/will be assigned by developers for the projects in which Dutch suppliers in value chain with much more opportunities. In particular, Netherlands is well known for its expertise on providing vessels of geological survey, turbine, foundation T&I, cable laying and O&M service, as well as the manufacturers of hardware, components and handling systems with innovation. This will be the priority area with chances for Dutch companies. On the other hand, any kind of underwater (marine) technology such as hydrodynamic testing (simulation), cable inspection and repair, natural-inclusive scour protection and noise mitigation technology are also with huge potential in the future for Dutch companies or knowledge institutes. In Taiwan, Metal Industries Research & Development Centre (MIRDC) play a vital role in the development of offshore wind in Taiwan in charge of marine technology industrial innovation center, and offshore wind training which will require Dutch knowledge in the domain of marine technology and crew trainings.

Taiwan market for offshore wind is currently like any other European /international market with so much investment flow and attention from foreign leading developers, therefore Dutch companies should be more aware that Taiwan has become a very competitive market with many key international players based locally so that it's suggested for companies to have full involvement, more investment or company representative installed locally if active and positive business development is pursued.

2. *Will the Partners for International Business (PIB) strengthen the participation of the Dutch in the OWS in Taiwan?*

Partnership in Business approved in June 2018 has provided a good instrument especially for branding or promotion activities in trade mission or trade fairs. PIB liaison also shared the regular market information or updates to consortium of PIB and answered the inquiries from PIB companies as customized service. From our observation, it would be more successful if PIB members can work more closely with those non PIB Dutch members being active in Taiwan to achieve the goal and work as a collective effort made by Dutch supply chain/Dutch industry.

Ideally, close communication among liaison, PIB cluster and coordinator is expected to give more insight in the risks and advise during implementation of the PIB Offshore Wind Taiwan. With quickly-changing news and information every day in Taiwan, it is getting more challenge to develop a business only based on seminars, workshops, expert meetings, participation in trade fairs sometime every year organized by PIB, and sometimes it is not easy to find a common interest for promotion within PIB. The main reason is that most Dutch companies have been in touch with local companies and further established their own contact or business, so that every company of PIB is currently at different stage for development. Sometimes, it even has conflict interest with other Dutch companies active in market. How to find a synergy for all is rather important for the future work. However, under G2G framework PIB government relationship has been kept stable and close with regular meeting or mission, so that there are more direct channels between government and business to have a dialogue on marker barriers for companies in need. PIB indeed facilitates larger awareness to other new comers in the Netherlands who like to get in touch with NTIO or HHWE for inquiring information and looking at business interest. From this perspective, I think PIB is helpful for more Dutch participating and working in market in particular for 2ed or 3th tier companies in value chain. They can explore and participate in market with guidance and resource through information and activities by PIB.

3. *In April this year the Bureau of Energy announced that another 5 GW offshore capacity will be developed which should be ready to operate between 2026 and 2030. Details for this will follow at the end of this year. However the BoE confirmed that the tenders will be open for foreign developers. Does this provide an opportunity for a Dutch (maybe Dutch-international) consortium to participate in the tenders?*

Yes, Bureau of Energy will announce the post 2025 plan at Q4 this year and it would be an opportunity for Dutch developer like Shell to evaluate the participation in projects after 2025.

4. *Does a strong cooperation between Dutch government, industries and research institutions (Tripe Helix) contribute to a facilitated market entrance in the OWS in Taiwan?*

Since 2016 there are inbound or outbound delegations between Taiwan and the Netherlands at the level of government to government, knowledge institute to knowledge institute and companies every year. At certain close door event such as government to government (RVO, RWS, BoE) workshop, Dutch companies are always welcome to participate, and share their points of view. Knowledge institutes such as TKI Wop Zee, ECN, Marin also presented its expertise together with possible solution Dutch companies are able to offer in industry. Therefore, it is a positive interaction among government, industry, research institute and port authority so far, to demonstrate how Netherlands worked well from different dimension in offshore wind industry and how Dutch slogan "wind & water works" being successful in Europe.

5. *Are there any specific challenges for foreign companies when entering the OWS in Taiwan?*

Localization requirement is a challenge for foreign companies when entering into Taiwan market. Companies are requested to joint force with Taiwanese partners to fulfill localization relevance plan proposed by developer, and need to receive the permit from Industrial Development Bureau, MOEA as one of conditions approved for PPA. There are two main concerns from foreign companies (including Dutch companies) toward government policy in terms of localization in market:

(1) Rigidness of localization requirement would limit the flexibility to work with local industry:

Dutch companies are willing to provide technology transfer and seek for opportunity to cooperate with Taiwanese industry, for example on turbine blade, component, equipment or supportive vessels. But if Taiwanese companies are not able to invest, it will become a challenge for Dutch company to find a Taiwanese partner for joint venture as expected for localization. On the other hand, the shortage of local trained crews will be a problem foreseen in short term for implementing localization on local crew hiring on vessels.

(2) Clarity of local marine vessel regulation in urgent need for contractors:

The policy and regulation for marine regulation is not stable enough for companies working in market. Taiwanese government should set more clear rules of the vessel importation, for example flagging for smaller vessels with more predictable procedures and local content requirement (for example the crewing requirement) and should not change too frequently. In case of a shortage of a certain vessel type – for example Construction Support Vessel type – it should not be possible that vessels from China are completely blocked as this will create shortage of qualified special vessels and a monopoly position for the few owners, and thus higher prices all-over for Taiwan development.

2. Interview: Kees Mokveld, Liaison Officer Enterprise Europe Network (EEN) Sector Group Intelligent Energy, Netherlands Enterprise Agency, 18 June 2019

1. *What is the role and contribution of RVO, as a government institution, in the Partners for International Business (PIB) Offshore Wind Taiwan?*

The PIB has a total duration of three years. The main role of the RVO within the PIB is the cooperation between the Taiwanese and Dutch government, also known as the Government to Government (G2G) cooperation. Within the PIB there is also attention for Knowledge to Knowledge (K2K) and Business to Business (B2B). The activities are mainly developed by the companies participating in the PIB, whereas RVO as a government institution is more involved with the government relations to, for example, facilitate market access or share knowledge on regulation. RVO and the NTIO in Taiwan focus more on economic diplomacy with the Taiwanese Bureau of Energy as their most important partner.

2. *What are the opportunities and challenges for Dutch businesses operating or wanting to operate in Taiwan?*

Dutch knowledge institutions and offshore companies have specific knowledge about the ecologic aspect of offshore development. In that sense, there are opportunities for the Dutch to share their knowledge and innovative solutions. An example of this is 'bubble shields' that are used when monopiles are drilled in the sea bottom. As a country we are competitive in various parts of the supply chain, mainly in the construction of the wind farms and the operation & maintenance. In other parts, however, we have no competitive advantage, for example in the high tech elements of the generator. At the same time we are depending on the decisions of the project developers, which are influenced by the prices that suppliers offer. So, besides quality, competitive prices are important.

Two challenges for any foreign company operating in Taiwan are the required local content and the ban of certain Chinese vessels and products. The first as there is a shortage of skilled local people, making it difficult to meet the required conditions and quality. The shortage of specific products and vessels, which are produced by China, that exists due to the ban on Chinese products, complicates the development process as well. If The Netherlands start the actual development, these are challenges that need to be resolved. The NTIO in Taiwan has tried to solve this last issue with the asset of economic diplomacy. The main responsibility of the government in this sense is to take away any risks or challenges for companies.

3. *What is the future outlook for the Dutch offshore wind industry in Taiwan?*

The future for Dutch companies in Taiwan depends on many factors, some of which are external and cannot be influenced. At the same time, we do think that there are plenty of opportunities in general. For Dutch companies wanting to operate in Taiwan, it is important to understand the business culture in the country. For example, it is important to invest in trade relations to be able to achieve contracts. Companies should listen to and analyze the wishes of the Taiwanese and act to these wishes. In this, there is an important role for the local liaison officer in the NTIO that stays up to date on the most recent developments and plans in the offshore wind sector in Taiwan. For the new plans to develop more offshore capacity, it would be interesting if a Dutch consortium would obtain developing capacity as it would create opportunities for other Dutch companies operating in the sector.